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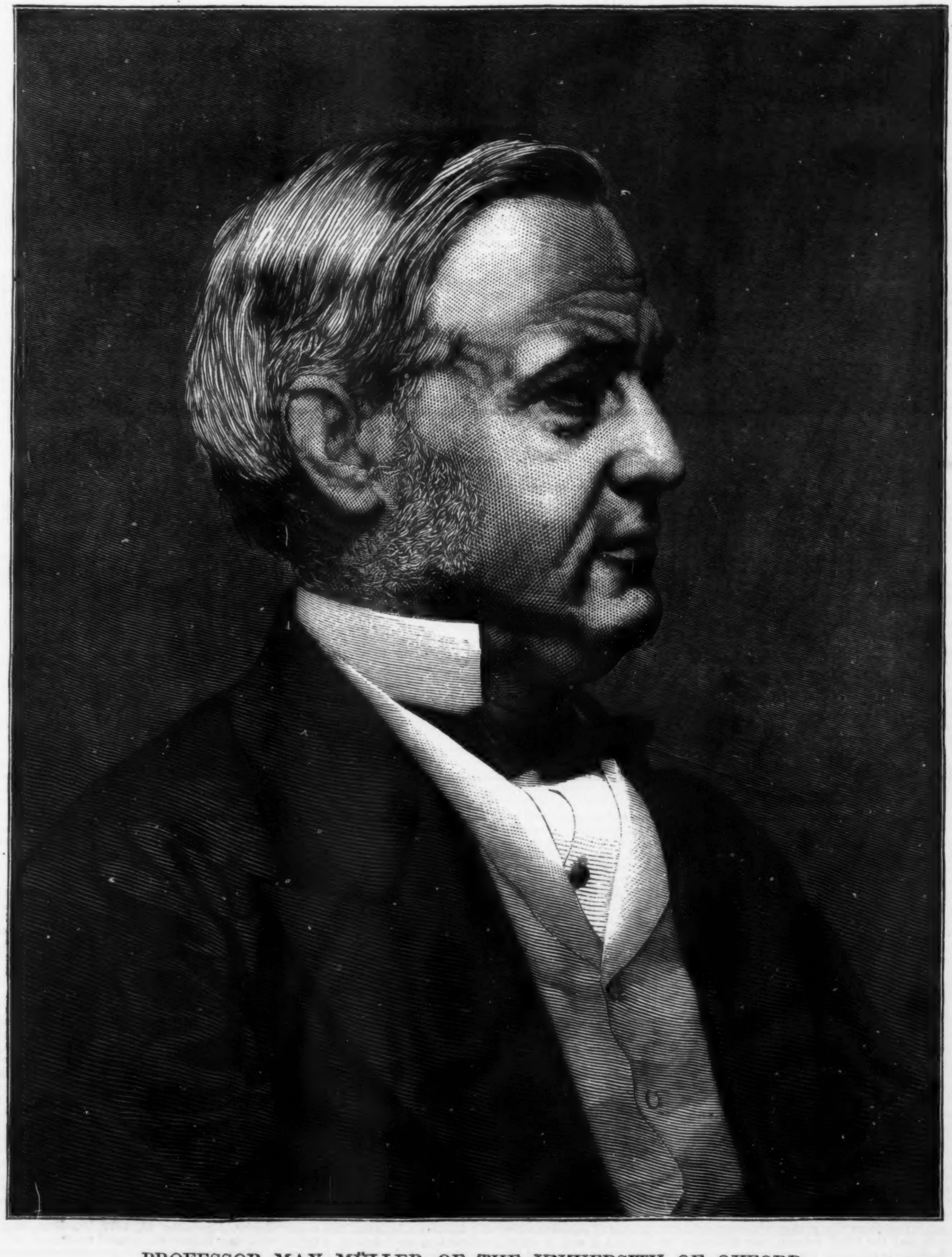
PROFESSOR MAX MÜLLER.

This eminent comparative philologist and philosophical student of general history combines a great knowledge of the Indian and other Oriental languages and their ancient literature with a genius for abstruse researches into the origin of metaphysical ideas and their symbols, and he is delivering a course of lectures at the Chapter-House of Westminster Abbey. The lectures form one series of those which were provided for by the will of the late Mr. Robert Hibbert, and which are designed to elucidate the history of religious thought and worship in all ages and among different races of mankind. The present course of seven lectures, by special permission of Dean Stanley, is delivered in the Chapter-House of Westminster Abbey on the Thursday of each week beginning April 25th. Professor Max Müller delivers each lecture twice on the same day to different audiences, at half-past eleven in the morning, and at five o'clock in the afternoon. His general subject for the whole course is "The Origin and Growth of Religion, as Illustrated by the Religions of India."

The particular subjects and dates for each of the seven lectures are as follows: 1. April 25, "On the Perception of the Infinite." 2. May 2, "Is Fetishism a Primitive Form



PROFESSOR MAX MÜLLER, OF THE UNIVERSITY OF OXFORD.

of Religion?" 3. May 9, "On the Sacred Literature of India, so far as it Supplies Materials for the Study of the Origin of Religion." 4. May 16, "On the Worship of Tangible, Semi-Tangible, and Intangible Objects." 5. May 23, "On the Ideas of Infinity and Law." 6. May 30, "On Henotheism, Polytheism, Monotheism, and Atheism." 7. "On Philosophy and Religion." A report of the first lecture was given by most of the daily papers, and its full text is published in the May number of the *Contemporary Review*.

We take this opportunity to present the portrait of Professor Max Müller, as one of the most accomplished scholars and authors in his own department of learning and mental science. He is a native of Anhalt-Dessau, and was born in 1823. He was educated at foreign universities, in Germany and in Paris, but came to England in 1846, and was soon afterward engaged, by the then Government of the East India Company, to prepare an edition of the "Rig-Veda," which may be called the Hindoo Bible, to be published at the cost of Government. He resided at Oxford while so employed; and having for some time performed the work of deputy for the Taylorian Professor of Languages, was appointed to that University chair in 1854. Two years later, having meanwhile been invested with the degree of M. A. by decree of Convocation, he was appointed Curator of the Bodleian Library. He was a candidate in 1860 for the Boden professorship of Sanscrit, and has recently exchanged his former chair for the new one of Comparative Philology, undertaking at the same time an extensive task of literary editorship for a projected series of translations of the "Sacred Books" of the world. His essays on philological and other topics, collected under the title of "Chips from a German Workshop," and those of a more systematic character on "The Science of Language," have gained high favor with a large circle of readers. Our portrait of Professor Max Müller is engraved from a photograph by Mr. Guggenheim, of Oxford.—*Illustrated London News.*

THE LIQUEFACTION OF OXYGEN AND HYDROGEN, AND THE SOLIDIFYING OF HYDROGEN.

By RAOUL PICTET.

HEAT being known to man as a sensation, it is no wonder that philosophers should so long have mistaken it for some special agent. But, at last, the revelations of sensation were found insufficient to explain many phenomena connected with the manifestations of heat. Hence arose the science of calorimetry, whose business it is to treat of the relations existing between the elastic force, the volume, and the temperature of bodies. Heat that cannot be tested by sensation was then called latent heat, a felicitous expression, which was the harbinger of a host of fresh discoveries in every scientific field. The mechanical theory of heat, the immediate outcome of the theory of latent heat, seems destined to explain every difficulty connected with this hitherto abstruse subject. The mechanical theory of heat does away with heat as a special agent, and declares that heat is nothing more than a *molecular and atomic motion;* so the study of heat has now become the study of molecular and atomic motion. It is no exaggeration to say that the moving atoms are now as clearly visible to the eye of scientific analysis as though they could be brought under microscopic investigation.

The theory of atomic motion is a new element in the long pending discussions on the physical constitution of bodies, an element of such paramount importance that atomic motion and the nature of matter may be considered as almost one and the same subject. M. Clausius' theory of gases is perhaps the most telling deduction yet made from that of atomic motion.

My purpose is to take up some of the phenomena which have hitherto been considered exceptions to the Clausius theory or to accepted physical laws, and experimentally to prove that they form no exceptions to those laws. A few words concerning these phenomena may help the reader to apprehend the drift of this essay. Almost all known bodies may assume the gaseous, liquid, or solid state. In the same body, these three states are brought about by three different degrees of temperature; the solid state is the result of the lowest temperature, the liquid state of a higher temperature, and the gaseous of the highest temperature. The condition of a body depends on two forces often antagonistic—(1) atomic cohesion the result of attraction, and (2) atomic vibration the result of heat. This may be considered as a general law ruling matter.

Boyle's law on elastic fluids states that when the temperature remains constant, the elastic force of a gas is inversely proportional to the volume it occupies. Boyle's law would only be accurate for a gas of ideal purity. Now, M. Regnault in his memorable experiments on the compressibility of gases has brought out an important fact, viz., that gases nearing the point of liquefaction decrease in volume more rapidly than Boyle's law indicates. This accelerated decrease of volume at liquefying point is caused by the force of atomic attraction coming more rapidly into play as the gas is condensed into a liquid, and thus accelerating, in opposition to Boyle's law, the decrease of volume.

All the vaporous forms of known liquids, such, for instance, as those of mercury, water, alcohol, sulphurous acid, and carbonic acid, undergo the same influence; they all decrease in volume more rapidly at liquefying point than would a perfect gas.

The gases hitherto called *permanent*, because they had not been liquefied, *i.e.*, hydrogen, oxygen, nitrogen, seem also to form an exception to Boyle's too absolute law; for at liquefying point their decrease of volume is *retarded*.

And this brings us to investigate the phenomena of cohesion which have led me to find out the laws wherewith I might liquefy and solidify the so-called permanent gases of oxygen, hydrogen, and nitrogen.

If, in permanent gases, the cohesiveness of gaseous molecules were of itself sufficient to cause cohesion, under strong pressures cohesion would not fail to take place.

M. Regnault's suggestions induced M. Natterer, of Vienna, to try the effect of enormous pressures on hydrogen, oxygen, and nitrogen. In 1854, M. Natterer applied a pressure of 2,790 atmospheres to these permanent gases.

His mode of treatment was the following:—Into a receiver, measured quantities of hydrogen were successively introduced, say ten measures of hydrogen, oxygen, or nitrogen at a time. A very delicate manometer registered the pressure for every fresh supply of hydrogen.

In the following table the first columns show the *measures* of hydrogen, oxygen, and nitrogen introduced into the receiver; the second columns the *pressures* corresponding to those measures, and the third columns the *differences* between the atmospheric pressures for every ten measures of gas.

This table proves that Boyle's law is not true as soon as a pressure of 100 atmospheres is reached.

Hydrogen			Oxygen			Nitrogen		
Measures	Atmospheric pressure	Difference	Measures	Atmospheric pressure	Difference	Measures	Atmospheric pressure	Difference
0	0	8	0	0	7	0	0	5
8	8		7	7		5	5	
18	18	10	17	17	10	15	15	10
28	28		27	27		25	25	
68	68	10	157	157	10	75	75	10
78	78		167	167		85	85	
128	134	12	227	232	11	225	240	12
138	146		237	243		235	252	
238	274	13	277	287	11	275	306	15
248	287		287	298		285	321	
358	438	16	657	382	12	355	444	22
368	454		367	394		365	466	
418	539	17.	417	463	16	415	600	30
428	556		427	479		425	630	
458	608	19	457	530	24	455	720	35
468	627		467	563		465	764	
488	665	20	487	614	27	485	840	42
498	685		497	641		495	882	
538	775	24	537	764	30	535	1095	64
548	799		547	800		545	1159	
598	930	28	597	1010	46	595	1546	94
608	958		607	1056		605	1640	
668	1134	30	647	1284	70	645	2040	110
678	1164		657	1354		655	2150	
758	1434	37				675	2394	128
768	1471					685	2522	
828	1701	40				695	2654	136
838	1741					705	2790	
878	1904	44						
888	1948							
908	2044	54						
918	2098							
948	2277	70						
958	2347							
978	2505	89						
988	2594							
998	2689	101						
1008	2790							

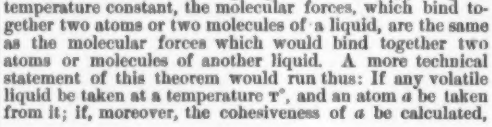
For relatively moderate pressures, oxygen is closer than hydrogen to the principle of Boyle's law, viz., that with a constant temperature the *elastic force* of a gas should vary directly as the *quantity* of that gas contained in a given receiver. But still, for high pressures, oxygen also is an exception to Boyle's law, and when 657 measures have been compressed, the pressure registered by the manometer is 1,354 instead of 657, which Boyle's law would bid us expect. Again, 657 measures of hydrogen show a pressure of 1,104 atmospheres, and 657 measures of nitrogen show a pressure of 2,156 atmospheres.

These results expressed by a curve whose abscissæ represent the compressed gas-measures, and whose co-ordinates express the corresponding pressures, show a manifest tendency toward a limit of compressibility which cannot be passed. This limit is the point where the curve is an asymptote to the vertical co-ordinate. Then, for any increased quantity of gas in the receiver, the pressure is infinitely increased. Such is the case when the gaseous molecules have been pressed down into absolute contact. The intermolecular spaces being reduced to nothing, the volume of the gas cannot be further reduced on account of the impenetrability of matter.

The above figures clearly prove that the molecules of the permanent gases must repel one another with considerable force, since 10 measures of oxygen show an increased pressure of 70 atmospheres, and 10 measures of nitrogen show an increased pressure of 110 atmospheres, facts which seem to invalidate the hypothesis of universal molecular cohesiveness.

The inference to be drawn from these experiments is, according to M. Clausius, that the molecular cohesiveness of permanent gases is next to nothing, and that their departure from Boyle's law comes from the infinite smallness of their molecules. But in vapors whose molecules are relatively large, cohesiveness would operate even under weak pressures, a fact which would explain their liquefying under pressure sooner than consonant with Boyle's law.

I have shown in a foregoing work that, supposing the temperature constant, the molecular forces, which bind together two atoms or two molecules of a liquid, are the same as the molecular forces which would bind together two atoms or molecules of another liquid. A more technical statement of this theorem would run thus: If any volatile liquid be taken at a temperature T°, and an atom *a* be taken from it; if, moreover, the cohesiveness of *a* be calculated,



that cohesiveness will be found to be the same for all liquids. This law proves that the liquid state is restricted to a fixed power of cohesion K, which acts at a distance L between two molecules. This condensation or volatilization at T° *must depend on* K. No other theory of condensation stands investigation.

The only known force antagonistic to cohesion is heat, giving to molecules or their atoms a pendulous motion, the amplitude of which is a function of their temperature. Considering the phenomena of latent heat such as they have been tabulated by M. Regnault, considering the laws of vaporous tension and dilatation under heat, I venture on the hypothesis that temperature is *directly proportional to the amplitude* of the atomatic heat-wave.

Shall we maintain that in a body standing at T all its component elements will vibrate with equal amplitudes? Assuredly not, for there is an intermolecular interference of heat-waves which gives to *this* molecule a greater vibratory amplitude, and to *that* a less than my law would assign to them were they independent one from another. A *mean* vibratory amplitude taken from all the atomic vibrations of a body represents the *temperature* of a body. In other words, the mean vibratory amplitude expresses the dynamic resultant of the atomic vibrations constituting the sum of the vibratory forces, in a body. This sum of vibratory forces is called the *potential* of a body.

The above theory may be easily proved experimentally. Take, for instance, any vapor under pressure P and at temperature T. The intermolecular space is here inversely proportional to the number of the molecules. In other words, double the number of the molecules, and you thereby halve the intermolecular spaces. Call K (see diagram) the fixed power of cohesion acting at a distance L between two molecules A B, and on which condensation must depend, T being the temperature and *l* the amplitude of the vibration corresponding to T.

The diagram represents two molecules of the vapor under the pressure at the temperature T. The distance between A and B is A B, a distance which may be increased or decreased by an increase or decrease of pressure. Call L the minimum distance at which cohesiveness acts in order to bring A and B under the fixed cohesive power K, and let A B'' equal *l*, the amplitude of the heat-wave proportional to the temperature T. Evidently, when the pressure leaves B at B, liquefaction cannot take place by cohesiveness, which, in this case, is inferior to K.

Increase the pressure to P', A B will be reduced to A B'. Then *l*, being equal or less than L, and cohesiveness equaling K, B rushes on to A, and forms with it a liquid molecule. The two molecules in their approach will develop much heat, since the first oscillation being A B' will almost immediately afterward be reduced to A B''. The *vis viva* lost by the molecules and given out to the walls of the receiver represents the latent heat of condensation, *i. e.*, the work of cohesiveness between the limits A B' and A B''.

The variations of volume of a gas and of the liquid into which it is condensed allow the observer to determine the relation of the lengths $\frac{A\ B'}{A\ B''}$. The change of volume is considerable for liquids of mean volatility.

Bearing in mind Boyle's law, the relation $\frac{A\ B'}{A\ B''}$ and the K of molecular cohesiveness, we can realize the conditions which bring about the liquefaction of a vapor.

Press the molecules A, B, to the limit of cohesion B'; the temperature being constant, the pressure will be constant too, whatever the quantity of vapor pressed down. P' being the maximum pressure, the *latent heat* set free is a function of the lengths A B', A B''; is a function of the number of the condensable molecules and a function of K which tallies with the condensing temperature T. An experimental proof of this statement may be given. For such a proof, let us take a few liquids in the order of their volatility. Generally, the intermolecular cohesiveness of a body depends on the density of the latter. The more stable a liquid or the higher its boiling point on the thermometric scale, the greater the cohesiveness of its molecules. Hence the fact that in a dense liquid, the temperature T being constant, the distance of molecular attraction would be greater than in a liquid of less density. Take, for instance, water and sulphuric ether, and press down their vapors at a temperature − 30° C. The distance A B' for water will be greater than for ether; and thus, according to Boyle's law, the pressure of a vapor of water will be less than that of a vapor of ether. In short, vapor pressures vary as their volatile power.

Now, the length A B' is registered by 31·548 millimeters of mercury for *water*, and 634·80 millimeters of mercury for sulphuric ether; so for both liquids the pressure is not identical. But, on the other hand, the length of their heat-waves A B'' will be equal for both liquids after condensation. Thus, the *latent heat* set free in both these cases will vary (1) as the *number of molecules* liquefied by their cohesiveness, (2) as the *constant* K tallying with the temperature T, and (3) as the *function* binding increasing cohesiveness to the different intermolecular distances between A and B. If, in succession, we compare water to sulphuric ether, to sulphurous acid, to ammonia, to carbonic acid, we see that the distance A B' at which condensation takes place gets smaller and smaller as a more volatile liquid is taken. At freezing point condensation pressures are registered by millimeters of mercury as follows: Water, 4 millimeters; sulphurous acid, 1·165; methylic ether, 1·879; carbonic acid is condensed by a pressure of thirty atmospheres. It is manifest that the less condensable a vapor the greater is the difference between its volume and the liquid into which it has been condensed, a fact proving that the essential difference between one vapor and another is that of *molecular cohesiveness*.

In order, therefore, to *condense two gas molecules* A, B, two conditions must be realized. 1. Press A toward B, so that the distance A B' to which A and B are brought may be under the influence of K the minimum force of condensing cohesiveness. 2. It is *absolutely necessary* that the distance A B' should be greater than A B'' the amplitude of the heat-wave. For if the molecular cohesiveness of a gas be small and the *amplitude* A B'' of the heat-wave tallying with the temperature T be greater than A B', liquefaction becomes impossible, because in order to prevent the heat-wave counteracting K, A and B must be kept out of reach of K, and thus cannot cohere, a dilemma both alternatives of which bring about *non-cohesion*.

The second condition of liquefaction fully explains all the phenomena relative to the permanent gases oxygen, hydrogen, and nitrogen. In order to condense these gases, it is not enough to subject them to enormous pressures; the amplitude *l* of the heat-wave must be made less than A B' by lowering the temperature. Then A B'' being small, as small as possible, A B' the distance at which the molecules A, B, become condensable by K will be larger than A B''. Thus, and *thus alone*, can liquefaction be brought about.

Hitherto it was thought that pressure and temperature were so bound together that the one might be made to do the work of the other. This belief was, as I have shown, but partially true.

As all volatile liquids enable us to tabulate the tensions of their saturated vapors, we can ascertain the relation between the pressure P and the temperature T. But these tables cannot be made up for high temperatures, and experience shows that at a certain temperature the liquid suddenly passes into vapor without changing its volume. For water, the point of change from the liquid to the vaporous state lies between 400° and 500° C. For ether, the liquid limit is lower, and for sulphurous acid it does not reach 250°. For carbonic acid and the protoxide of nitrogen it is still less, and lastly, for hydrogen, oxygen, and nitrogen the liquid limit is at a point lower than the temperature of the ambient air. The foregoing facts show the universality of the law of cohesion, and have proved to me that the liquefaction of the permanent gases was to be obtained by the simultaneous employment of two agents, (1) *great pressure*, (2) *great cold*. The analytical method which has opened my eyes to these phenomena will be rich in results in similar fields of inquiry. All the laws relative to the variations of latent heat both external and internal, to the tensions of volatile vapors, to the mixture of gases with vapors—in short, the whole of calorimetry and thermo-dynamics—must henceforth be examined in the light of the general principles I have laid down.

A description of the machinery used by me for the liquefying of hydrogen and oxygen and for the solidifying of hydrogen would be out of place here. An extract from the *Journal de Genève*, December 23, 1877, describes accurately enough what may interest the general reader:

"By a double circulation of sulphurous acid and carbonic acid, this latter gas is liquefied at a temperature of sixty-five

degrees of cold, under a pressure of from four to six atmospheres. The liquefied carbonic acid is conducted in a tube four meters long; two combined pumps produce barometric vacuum over that acid, which solidifies in consequence of the difference of pressure. Inside the first tube, containing, as aforesaid, solidified carbonic acid, passes a tube of smaller diameter, in which a current of oxygen is caused by a generator containing chlorate of potash, and in the form of a large-sized thick-walled shell. Pressure may be brought up to 800 atmospheres. Yesterday morning, the 22d of December, under a pressure of 300 atmospheres, a liquid jet of oxygen gushed out of the extremity of the tube at the very moment when the compressed and cooled-down gas was passing from its high pressure to atmospheric pressure. To the beholder the gushing liquid oxygen is very much like a great rush of hot water from the hot-water cock of a bath."

By a singular coincidence, M. Cailletet, of Paris, succeeded in *vaporizing* oxygen the same day as I *liquefied* it, and a few days later M. Cailletet *vaporized* hydrogen and nitrogen. The experiments were made in the laboratory of the Ecole Normale, in the presence of MM. Boussingault, Henri Sainte-Claire Deville, Berthelot, Mascart, etc. These eminent men, says the *Journal des Debats*, declared themselves satisfied that the nitrogen was reduced to the condition of *little drops*, while the hydrogen became visible in the form of a *vapory* cloud.

The method employed by M. Cailletet is that of a sudden reducing of a great pressure on the oxygen to that of atmospheric pressure. This sudden slackening of pressure produces a great external work, and is thus the cause of a great lowering of temperature. The refrigeration consequent on the slackened pressure may easily reach —200° C. below the initial temperature of the gas. The sudden reduction of 250 atmospheric pressures condenses the gas into a vesicular or vaporous form. This misty state of the gas is extremely transitory; for radiating heat almost instantaneously makes the drops of vaporous gas pellucid—in other words, brings them back to their gaseous form. In my researches, I have aimed at converting oxygen into a relatively permanent liquid to be collected in a receiver, so as to be able to measure its density and maximum tension.

On the 11th of January I forwarded from Geneva the following telegram to M. Dumas, Secrétaire Perpétuel de l'Académie des Sciences:

"I have just liquefied hydrogen with a pressure of 650 atmospheres and 140 degrees of cold. The gas *solidified* under the effect of evaporation. The jet had a flashing bluish color somewhat like steel. The gushing jet fell on the ground, making a noise not unlike a heavy charge of shot, accompanied by a strident hiss. Lumps of hydrogen were kept intact in the tube."

M. Dumas immediately laid my discovery before the Société d'Encouragement. From a report of a lecture of his on the subject I take the following lines:

M. Dumas, the illustrious chemist, began by reminding his hearers, with legitimate pride, that he had foreseen some forty years ago, in his *Traite de Chimie*, that hydrogen was the gaseous form of a *metal*. After dealing at some length with the inductions which had led him to that conclusion, M. Dumas laid some stress on the distinction to be made between M. Raoul Pictet's and M. Cailletet's experiments. M. Cailletet has proved the *possibility* of reducing all gases to the liquid and the solid states. M. Pictet has *really* reduced the permanent gases to the liquid and the solid states."

And now to conclude. I here beg to thank the scientific world for the handsome welcome they have given my discovery. Still, the scientific world is not the world. A suppressed titter has rippled on the faces of the ignorant, followed by the query; "*What's the use of it?*" Well, it is perhaps the fault of the scientific world if so groveling an exclamation is all but universal. Books, and especially manuals treating of physics, chemistry, and other sciences, lay more stress on tangible results than on the workings of the creative mind. Is it astonishing that man, who is naturally prone to value none but paying facts, should, when left to the mercies of a practical manual, remain unsympathizing whenever his attention is called to the laws which are at the root of creation? The philosophical temper which reverences God on account of the perfection of His thought ought to be the fruit of scientific education. Science is a religion which can and ought to make man God-loving, by sedulously turning his mind to the divine first principles which rule the world.—*Nineteenth Century*.

LIQUEFACTION OF GASES.

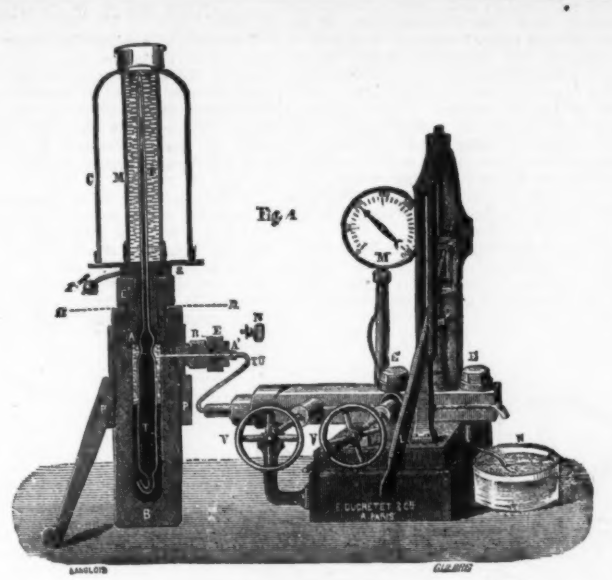
IT was reserved for Dr. Andrews to show experimentally that the liquid and gaseous states are perfectly continuous. His conclusion that every body, whether liquid or gaseous, has its own crictical point, contained the germ which, in its development, has ultimately led to the liquefaction of the "permanent gases." It follows from these memorable experiments that if a gas be kept above its critical temperature, no amount of pressure will be able to liquefy it; the most that can be done is to reduce it to a homogeneous body, which is neither a gas nor a liquid. If while it is in this neutral state the temperature be lowered, it will condense into a liquid; but if only the pressure be diminished, it will return to the gaseous state.

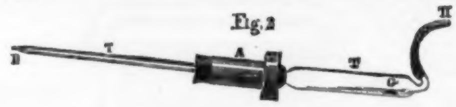
Here, then, at last we see the two conditions necessary to bring about liquefaction; viz., high pressure and low temperature. Dr. Andrews clearly apprehended these two conditions, for we find him subjecting oxygen to pressures exceeding any used by Faraday, while surrounding the gas with one of the most powerful refrigerating agents known, viz., a mixture of solid carbonic acid and sulphuric ether. Still his endeavors met with no success; oxygen gave no tokens of tractability.

M. Berthelot, the eminent French chemist, still more recently, carried the pressure up to 800 atmospheres, but without effecting liquefaction.

It occurred, independently, to M. Louis Cailletet, of Chatillon-sur-Seine, and M. Raoul Pictet, of Geneva, that the incoercible gases might yield to the intense cold that would be produced by allowing them *to expand suddenly* when compressed to a very high degree. According to Poisson's formula, this expansion should lower the temperature of the gas by about 200 degrees Centigrade. Both set to work and devised apparatus essentially differing from each other, but in both of which the embodiment of this principle forms a salient feature.

It is not to be supposed that M. Cailletet's success is the mere outcome of a fortuitous combination of circumstances. There are instances of this happy chance in the history of scientific discovery, but they are few. His success is entirely the result of a well-directed and sustained investigation. At different intervals during the last ten years this subject has engaged his attention. Availing himself of the mechanical power at his iron works at Chatillon, he collected





CAILLETET'S APPARATUS FOR THE LIQUEFACTION OF GASES.

a large amount of data, which, in the true spirit of a physicist, he kept by him until perfectly satisfied that he had finally solved the problem. This was on the 2d of last December; on the 3d, he wrote a short note to M. H. Sainte-Claire Deville, in which he states with pardonable enthusiasm that he had succeeded in liquefying carbonic oxide and oxygen. As he was at that moment a canditate for a seat in the Mineralogical Section of the Academy of Sciences, and did not wish his latest discovery to influence his election, he advised M. Sainte-Claire Deville to seal his letter and remit it to M. Dumas, the perpetual secretary of the Academy. Nearly three weeks later, on December 22d, M. Pictet communicated his results to the secretary, and singularly enough, the two papers were read at the same meeting of the Academy, viz., that held on December 24th. The priority in this very close race thus belongs to M. Cailletet, but this does not detract one tittle from the merits of M. Pictet's labors.

M. Cailletet's apparatus will be understood from the accompanying illustration, Fig. 1. A tube, T, Fig. 2, of very fine bore toward its upper extremity, and capable of supporting a pressure of 500 atmospheres, is partly filled with the gas to be liquefied. The lower portion of the tube expands to form a capacious bulb, which is filled with mercury, and inserted in a reservoir containing mercury and water. The walls of the reservoir are of steel, and sufficiently thick to allow pressures of 800 atmospheres to be used with perfect safety. The water is forced in by a strong pump, and, according as it enters, the mercury rises in the capillary tube, compressing the confined gas at the same time. A pressure of 200 atmospheres is attained by a few strokes of the pump, and is recorded by a metallic manometer. By means of a plunger, V, the pressure may be very gradually increased up to 500 atmospheres. Meanwhile the capillary tube may be surrounded by a freezing mixture, or by water at any desired temperature.

In the case of most gases, the manometer remains stationary when a certain pressure has been reached. This phenomenon, which is at variance with Boyle's law (a law absolutely true only for a perfect gas), occurs as soon as liquefaction begins. When an appreciable quantity of the gas has been liquefied, upon gradually diminishing the pressure the liquid begins to boil and returns to the gaseous condition. But if the valve V' be suddenly opened, the gas will as suddenly expand, and, undergoing a very considerable reduction of temperature, a portion of it will be liquefied, filling the upper part of the tube with a sort of cloud or mist. These effects are readily seen with nitrous oxide and acetylene, and may be easily exhibited to an audience by projection on a screen.

In the case of the other gases, the liquefaction has not yet proceeded further than its incipient stage. Thus oxygen under a pressure of 270 atmospheres and a temperature of —29 degs. was still gaseous; but on suddenly opening the valve V', the tube was filled with a cloud, which denoted a commencement of liquefaction, if not of actual solidification, as some have thought. M. Cailletet is now constructing an apparatus with which he hopes to clear away this doubt and also to verify that the gas is not converted into ozone during compression. The same nebulous phenomenon occurs even when the oxygen is not surrounded by a cooling mixture, provided time be allowed for it to lose the increment of temperature arising from its compression.

In the experiments which were made in the laboratory of the Ecole Normale, Paris, on December 30, in presence of several of the leading men of science, nitrogen was subjected to a pressure of 200 atmospheres and the temperature of liquid sulphurous acid (—29 degs. C.) without any signs of giving way. On opening the valve, tiny drops of an appreciable volume were visible for about three seconds. Hydrogen, as anticipated from its close resemblance to a perfect gas, showed itself the most refactory of all the gases; still when compressed to 280 atmospheres and suddenly released, it assumed, though only for an instant, the form of a very fine, extremely tenuous mist. To leave no doubt on the matter and to satisfy the physicists present, the experiment was repeated several times, and invariably with the same result.

On January 14th, M. Cailletet experimented with atmospheric air. Having removed all traces of moisture and carbonic acid, and introduced it into the capillary tube, he surrounded it with liquid nitrous oxide. When the manometer recorded 200 atmospheres, streams of *liquid air* flowed down the sides of the tube. The pressure was increased to 310 atmospheres; the mercury then having risen to the cool part of the tube, its upper surface was frozen; and on the prompt removal of the refrigerating substance, the meniscus was observed to be covered with a layer which was believed to be frozen or *solid air*.

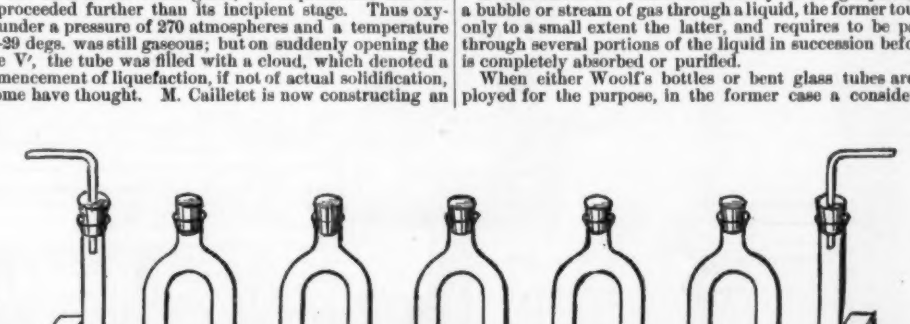
M. Pictet has obtained not only the cloudy appearance referred to above, but real jets of liquid oxygen and even miniature showers of hydrogen hail. Both physicists will doubtless continue their experiments until they have completely solved this great problem of modern physics, that is until they have succeeded in fixing liquid oxygen, nitrogen, and hydrogen for use in the chemical laboratory. In an early number we shall describe M. Pictet's apparatus and summarize the results he has obtained. The apparatus shown in Fig. 1 is the original one used at the experiments made in the Ecole Normale, and has been constructed specially for physical laboratories. MM. Ducretet & Co. are the constructors.—*Engineering*.

A GAS-ABSORBER.

By G. GORE, LL.D., F.R.S.

EVERY chemist is well aware that by the single passage of a bubble or stream of gas through a liquid, the former touches only to a small extent the latter, and requires to be passed through several portions of the liquid in succession before it is completely absorbed or purified.

When either Woolf's bottles or bent glass tubes are employed for the purpose, in the former case a considerable



IMPROVED GAS-ABSORBER.

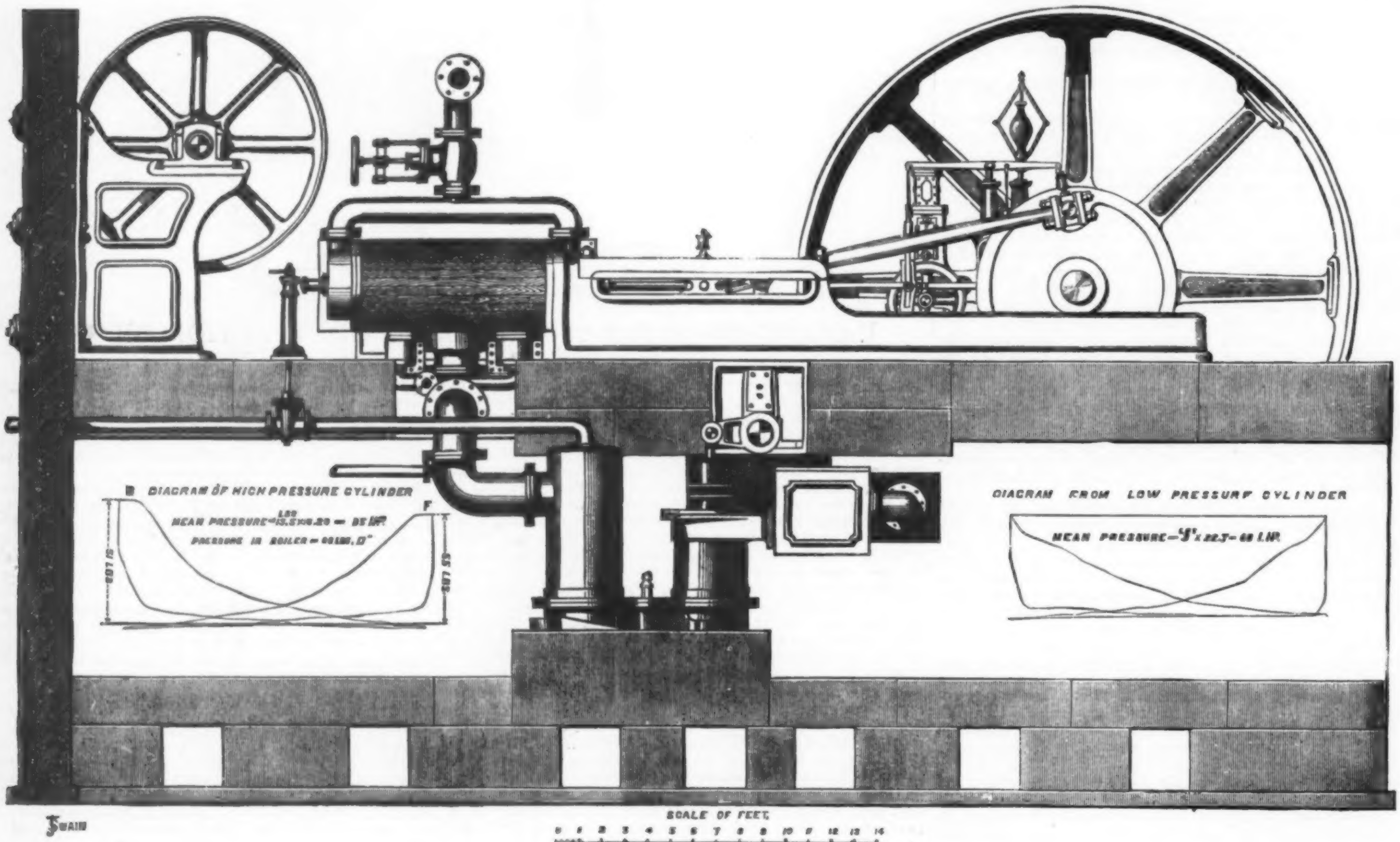
bulk of liquid must be used, and in both cases a number of junctions must be made with the different parts of the apparatus, and a proportionate risk of leakage incurred. I have therefore constructed the apparatus shown by the annexed sketch, for the purpose of quickly saturating a small bulk of liquid with a gas, or speedily absorbing a small quantity of gas by a liquid, without requiring many junctions to be made. It consists of a single glass tube, of about half an inch external diameter, bent into a series of four or six double curves, the upper part of each of which is provided with a neck (closed by an India-rubber bung), so that each limb of the tube may be readily cleaned. The tube is supported and kept steady in the manner shown in the sketch.

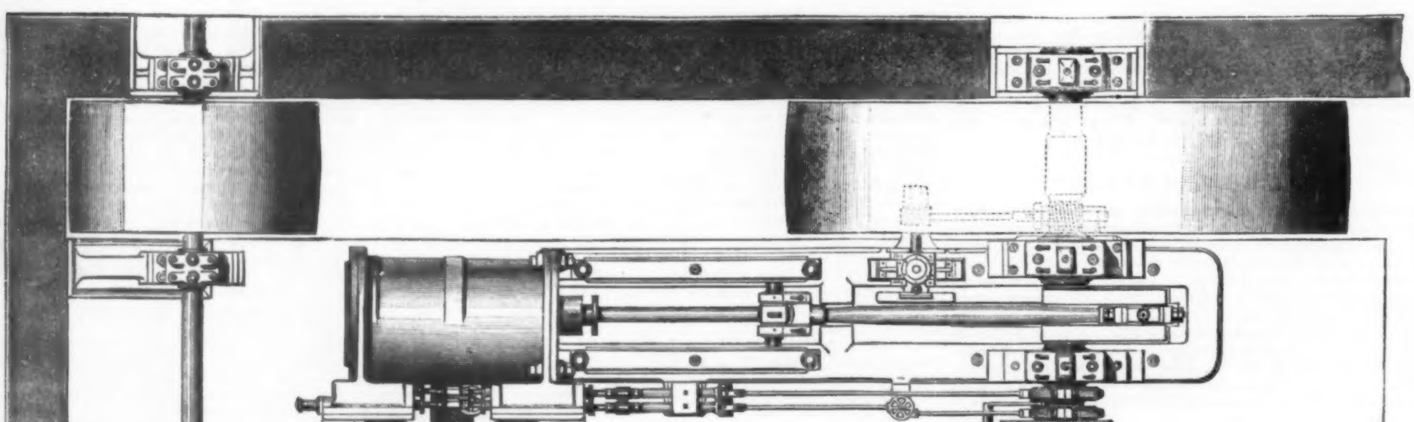
Having used the apparatus, and found it very effective and convenient for the intended purpose, and having been unable to find such an arrangement described in any catalogue of chemical apparatus, I have ventured to publish this description.—*Chemical News.*

NEW 500 H. P. COMPOUND ENGINES.

Engines of a high class have not been very extensively adopted in Yorkshire, but the necessity for economy in fuel even in the coal districts is effecting that which the textile manufacturer's need of uniformity of velocity at which his machinery should be driven has, generally speaking, failed to do. The engines which we illustrate this week have been built by Messrs. Pearson & Spurr, of Birstall Foundry, near Leeds, and erected by them at the Queen Street Mills, Batley, of Messrs. R. Brearley & Sons. They are from new designs by Mr. G. Sellers, and are intended to work up to from 450 horse power to 500 horse power. The mills, which are entirely employed in the manufacture of the heaviest classes of woolen cloths, are at present driven by a beam engine, assisted by a horizontal engine; but as these are old and of insufficient power to drive the machinery in the extended mills, Messrs. Brearley decided upon securing engines which should work economically and, as nearly as practicable, uniformly, and for this purpose they have obtained the compound engines about to be described.

Both the high and low pressure cylinders are fitted with double-slide chests, the object of this being chiefly to secure short steam passages, more ready access to either valve, and to obtain a space between the chests where the rod, supported by two extra glands, should, by a suitable joint, be adjustable, in order to modify the relative positions of the pair of valves without taking off the steam chest covers. The slide valves are of the Meyer type, and are readily adjusted by means of the right and left hand screws, as seen in the plan. The high pressure cylinder is fitted with automatic expansion gear of the Allen type, controlled by a Porter's governor. The low pressure cylinder, it will be seen by the elevation which we published last week, is fitted with expansion gear, adjustable by hand, by means of the hand screw moving the joint block in the rocking quadrant near the governors, and by which





COMPLETE PLAN

NEW 500 H. P. COMPOUND ENGINE

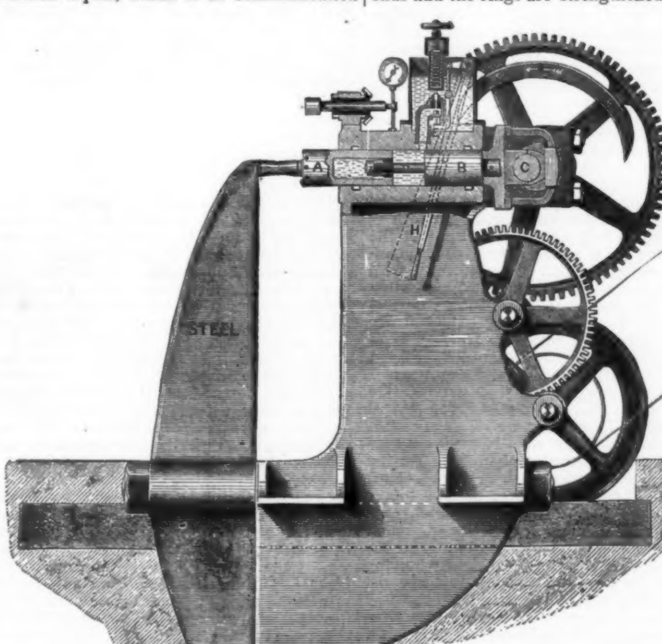
the length of stroke of the valve is adjustable. The exhaust from the high to the low pressure cylinder takes place through two separate pipes, and the cranks being separated by 140 degrees, and the low pressure cylinder ready to receive steam at the instant of its release from the high pressure cylinder, there is no necessity for any greater receiver than each pipe affords. As will be gathered from the diagrams engraved with the elevation, there is very little loss of pressure between the two cylinders. In front of the large drum which forms the fly-wheel is fixed a small engine, connected with the crank shaft by means of worms and wheels, for the purpose of turning the engines through a sufficient portion of a revolution to enable them to start. The worm that gears with the wheel on the crank shaft slides on its spindle, and by putting it into gear the attendant is enabled to start the engines without the assistance which he would otherwise require. By means of this small engine the fly-wheel was turned in its place, a temporary rest being fixed for that purpose. The power is transmitted by means of a fine leather belt, 48·5 ins. in width, running on the fly-wheel, which is 18 ft. in diameter, and a drum 9 ft. in diameter, on the main shafting, the bearings for which in the engine room are carried, as shown in our illustrations, upon a pair of heavy brackets. The high and low pressure cylinders are respectively 21 ins. and 40 ins. in diameter, and the stroke is 60 ins., the number of revolutions per minute being sixty. The steam ports are large, and in order to reduce their width as much as possible they are made of great length, those of the high pressure cylinder being 20 ins. by 1·75 in., and of the low pressure 30 ins. by 2 ins. The high pressure cylinder is connected to a dip crank, and the low pressure to a disk crank, the crank shaft being of sufficient size to give bearings 12·5 ins. diameter and 21 ins. in length. The connecting rods are forked at the small ends, the straps at this end being housed in channels in the rod, by which greater security is obtained. The cylinders are not jacketed, but they are well lagged, and the cylinders and steam chest covers are cast with recesses of 3 ins. in depth, the space being filled with non-conducting material, and covered by a thin cap. The condenser, which is of the injection type, is placed below the floor of the engine room, the air pump being worked by means of a rocking shaft connected by links to the crosshead of the low pressure engine.

As seen by the diagrams, the distribution of the steam leaves little to be desired. The vacuum is not so good as it should be, but this defect is attributed to leakage of the injection pipes, which are 360 ft. in length, and have been underground in use for the old engines for sixteen years. It need hardly be said that the design of the engines is thoroughly good, and the workmanship throughout is of a high character.—*Engineer.*

IMPROVED RIVETING MACHINE.

In the accompanying engraving we illustrate a riveting machine, which will work on copper rivets, and a considerable number of which are in use. The machine is driven by belt and gearing operating upon a ram, which is divided into two parts, A and B, coupled by a sliding bolt, D, the back part, B, receiving a positive motion from the crank, C. The space between the two parts of the ram is filled with water, or other suitable liquid, which is in communication with a valve loaded to the desired pressure. The back part, B, of the ram has thus a constant stroke equal to that of the crank, while the stroke of the front part, A, carrying the riveting die, is variable, and self-adjusting for any thickness of plate that may be inserted between the dies, the superfluous water being forced out under the loaded pressure into the small cistern. The return valve, E, is held open by the cam, F, during the entire back stroke, leaving free communication between the small cistern and the space between the two parts of ram, thus insuring the return to this space of any water discharged through the loaded valve. By pulling forward the handle, H, the return valve, E, is opened, and the water being no longer confined in the space between the two parts of ram, the front part, A, remains stationary, so that the motion of the riveting die can be arrested at any point. When the handle, H, is released, the valve, E, drops, and the action of the machine is resumed. The pressure gauge being in communication with the space between the rams indicates the precise amount of work being done at each stroke of the machine.

The water, it will be understood, is used solely for controlling the strains on the work being riveted. The machine has been very successfully used for riveting up locomotive fire boxes of copper, the rivets of which require about half as much pressure to close them as iron rivets need. Maccoll's Patent. Made by W. Muir & Co., Manchester, England.—*Engineer.*



IMPROVED RIVETING MACHINE.

ON THE CONSTRUCTION OF VESSELS TO RESIST HIGH INTERNAL PRESSURE.*

By MR. C. WILLIAM SIEMENS, D.C.L., F.R.S.

In constructing vessels intended to withstand a great internal pressure considerable practical difficulty has hitherto been encountered. If boiler plate is used in their construction, the seams of rivets are sources of weakness, and of uncertainty as to resisting power, increasing with the thickness of the plate required to withstand the intended strain. In consequence of the practical difficulties, it has been generally thought advisable to limit the diameter of cylindrical vessels intended to bear great strain, and to resort to a multitubular construction. But here, again, the difficulty of many joints is encountered, and the vessels constructed upon this principle necessarily occupy much more room than a plain cylindrical vessel would do. When cast iron is resorted to in the construction of such vessels, as in the case of hydraulic presses and accumulators, the thickness required is such as to render these vessels extremely ponderous and costly; and it sometimes happens that the fluid under pressure finds its way through the pores of the metal.

At the present time the occasions for the use of high-pressure vessels increase daily, with the application of compressed air as a motive agent, with the application of hydraulic transmission, and with the introduction of high-pressure steam for marine purposes, where the large diameters of the boiler shells required necessitate the construction of cylindrical vessels of great strength.

The writer's attention was specially directed to this subject last year by Colonel Beaumont, who asked him to advise regarding the construction of vessels of not less than a hundred cubic feet capacity, and capable of resisting an internal pressure of at least 1,000 lbs. on the square inch. The dead weight of this vessel was not to exceed $2\frac{1}{2}$ tons, as it was intended to act as a reservoir of highly compressed air, to supply air for working his tramway locomotive engine.

In designing this vessel, the writer acted on the principle of employing a metal to resist the bursting pressure that should combine strength and toughness in the highest degree, and so disposed that its continuity should not be disturbed by any sudden changes in dimensions or by perforations of any kind. The material selected was steel of such quality as to be capable of resisting a tensile strain of 45 tons per square inch, and of extending from 8 to 10 per cent. before breaking. The vessel is itself represented in Figs. 1 and 2. It consists of fourteen cylindrical rings of 40 ins. internal diameter and 12 ins. depth, rolled out of solid steel ingots in a tire mill, and of two hemispherical ends beaten out of steel boiler plate. The hemispherical ends and the rings are strengthened at the edges by projecting dwarf flanges. The only tooling necessary to these rings and ends consists in turning a V groove into each face, care being taken that all the grooves should be at the same distance from the center, irrespective of the precise diameter of the rings. Rings of well annealed copper wire $\frac{5}{16}$ in. thickness were prepared, the diameter of these rings being precisely the same as that of the grooves.

Two rings of cast steel, each perforated with twenty holes of $1\frac{5}{8}$ in. diameter, fit over the hemispherical ends, but rest chiefly against the projecting dwarf flanges of the same; through these holes twenty bolts of steel of $1\frac{1}{4}$ in. diameter, of such quality as to resist 50 tons per square inch, are passed, care being taken to enlarge the screw part of the bolt, in order not to weaken its total strength in that part, but to allow of uniform elastic action throughout its length. The different parts composing this vessel having been thus prepared, the vessel was built up as represented in the drawing, and the bolts gradually tightened to a point just sufficiently to resist the intended internal pressure. This being accomplished, the vessel was filled with water and the pressure of a hydraulic accumulator loaded to 1,000 lbs. per square inch was applied. No sign of leakage was observed, except at one point, where the thickness of the copper ring appeared to have been insufficient to fill the groove. This defect was remedied by passing the edge of a thin chisel in between the flanges, and pressing the coppering in that place by gentle hammering, which had the immediate effect of stopping the leakage. The internal pressure was thereupon gradually raised to 1,300 lbs. on the square inch, at which point nearly all the joints began to weep, showing that a point of pressure had been reached at which the bolts commenced to elongate. Each nut was thereupon drawn up another eighth of a turn, and the pressure again applied, when the vessel was found to be perfectly tight at the previous pressure of 1,300 lbs. on the square inch, but began to show leakiness at all the joints when the pressure reached 1,400 lbs. On lowering the pressure again to 1,300 lbs. on the square inch no further leakage was observed, showing that the joints had been completely closed again by the elastic pressure of the bolts.

Considering that the intended working pressure of this vessel is only 1,000 lbs. per square inch, it was thought unnecessary to draw the bolts any tighter, although, according to calculation, the rings as well as the bolts are capable of resisting with safety above 2,000 lbs. per square inch. It was thought safer on the contrary to allow the bolts to be drawn up to such a point only that if by any accident the pressure should considerably exceed the ordinary working limits they would yield by slightly elongating, and thus act the part of an elastic safety valve in allowing the fluid pressure to escape through the metallic joints. The great length of the bolts insures a sufficient elastic range of action for this purpose, and being made of steel containing $\frac{5}{10}$ per cent. of carbon, they will retain their elasticity for an indefinite length of time.

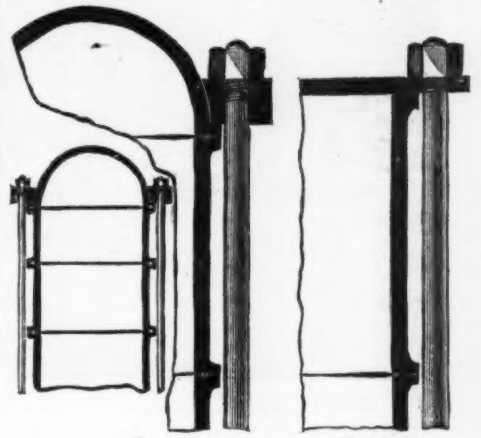


FIG. 1. FIG. 2.
VESSELS FOR HIGH PRESSURE.

This vessel, which was constructed at the Landore Steel Works, has now been delivered to the makers of the engine, Messrs. Greenwood & Batley, of Leeds; this engine will shortly be employed at Woolwich Arsenal as an air locomotive for shunting purposes. The writer is of opinion that the same principle of construction is applicable to hydraulic cylinders and accumulators.

In this case the longitudinal bolts need only be strong enough to tighten the copper joints, whereas the rings have to be made strong enough to resist the hydraulic pressure. Taking, for instance, a hydraulic cylinder of 2 ft. diameter and an internal working pressure of 2 tons per square inch, the rings have to be rolled of a thickness of 1·6 in., which corresponds to a working strain of 15 tons per square inch, or one-third of the breaking strain of the material composing the rings.

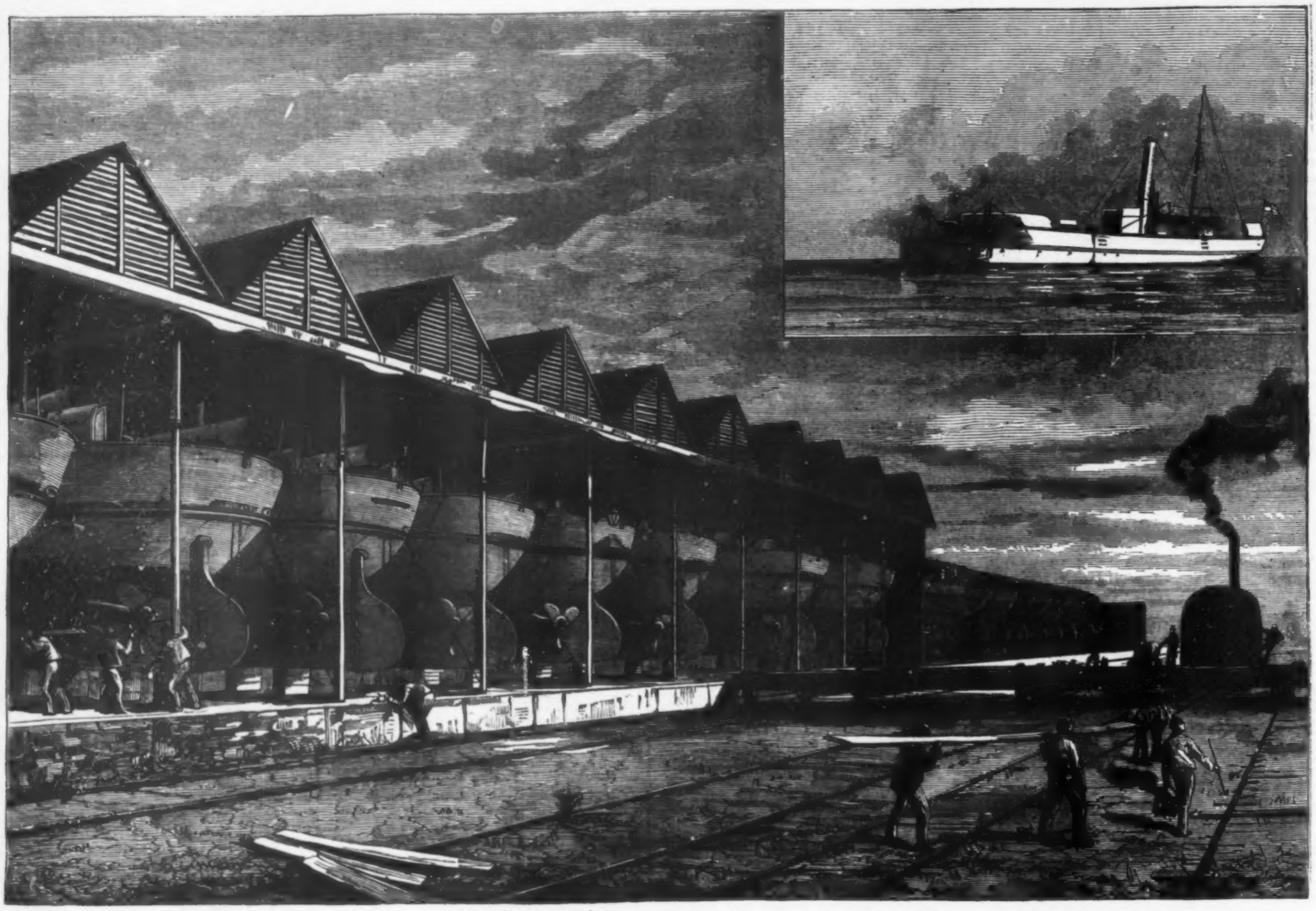
This press would give a hydraulic pressure of 904 tons, and would weigh probably not more than one-fourth of the weight of a press of the ordinary construction. The same argument would apply to accumulators of large dimensions, which could be built up of rings at a comparatively cheap rate, and of practically unlimited range. Diagrams 2 and 3 represent the application of this mode of construction to marine boilers. These boilers are necessarily of large diameter, and in constructing them of wrought iron, or even of mild steel, plates exceeding 1 in. in thickness have to be employed, and it is not easy to work and rivet plates of such dimensions, nor is the riveted seam nearly as reliable as that of thinner plates.

The diagram represents a boiler shell of 10 ft. diameter, of the proposed construction. It consists of twelve continuous rings of $\frac{7}{8}$ in. thickness of metal fastened together by sixty-four steel bolts of $1\frac{1}{16}$ in. diameter, which pass through the end plates, and thus bind the whole fabric together. These end plates are fitted with furnaces and steam tubes in the usual manner.

A boiler of this construction and of these dimensions could be safely tested up to 200 lbs. per square inch, the rings being sufficiently strong to withstand an internal pressure of 600 lbs. on the square inch; and it possesses, in common with the air-vessel already described, the advantage of leaking, through the yielding of the elastic bolts, long before there is the least danger of explosion. It possesses, moreover, the additional advantage that it can be carried in pieces to be put together *in situ*, thus facilitating carriage and avoiding the necessity of providing hatchways of extraordinary dimensions for putting the boilers on board. In order to prevent galvanic action between the copper and steel rings, it will be found desirable to calk the joints from within the boiler with India-rubber, or with string saturated with some resinous compound, or simply to brush such a compound into the joints from within the boiler.

The interest at present manifested in the substitution of steel for iron for engineering purposes has induced the author to bring this paper before the Institution without waiting for practical confirmation of the construction involved upon an extended scale; the question is one rather of mechanical detail than of principle, the object being to treat material in such a way as to develop its maximum of resisting power when applied to the construction of vessels to resist high internal pressure.

* Institution of Mechanical Engineers.



BRITISH STEAM GUNBOATS READY FOR LAUNCHING, PORTSMOUTH HARBOR, ENGLAND.

GUNBOATS.

In view of the anticipated war between England and Russia, great activity has of late prevailed in the British naval departments. Among the other warlike preparations which have been going on in Portsmouth Dockyard, arrangements are being made to get ready for sea the flotilla of iron gunboats which were built for service in the Baltic during the last Russian war, but most of which have since that time been lying ingloriously on the slips at Haslar. These are formidable little vessels of 254 tons displacement, with twin screws, and carrying each an 18-ton gun in the bows. They are called the Ant, Badger, Blazer, Bloodhound, Bonetta, Bulldog, Bustard, Comet, Cuckoo, Fidget, Hyæna, Kite, Mastiff, Pickle, Pike, Scourge, Snake, Snap, Tickler, and Weazel. The slips occupied by the gunboats are situated adjacent to Haslar Hospital. Each gunboat is placed under cover in a separate compartment, as shown in our illustration, and is entirely sheltered from the weather. The gunboats can be hauled up and down by machinery adapted to that purpose. It is understood, however, that only seven will be employed in active service upon the present occasion. Meantime it has been stated this week that a squadron of twenty vessels, consisting for the most part of ironclad ships, is to be at once formed for naval operations, it is believed in the Baltic.

BRIDGES IN INDIA.

At a recent meeting of the Institution of Civil Engineers, London, the papers read were descriptive of three bridges on the Punjab Northern State Railway, viz.: "The Ravi Bridge," by Mr. R. T. Mallet, M. Inst. C.E.; "The Alexandra Bridge, over the Chenab," by Mr. H. Lambert; and "The Jhelum Bridge," by Mr. F. M. Avern, M. Inst. C.E.

THE RAVI BRIDGE.

The bridge over the Ravi at Lahore consisted of thirty-three spans of 90 ft. in the clear and 97½ ft from center to center of the piers. The piers were of brickwork, each founded on three brick cylinders, sunk 70 ft. below the lowest water-level. Eight vertical tie-bars were built in the brickwork. The piers were protected from scour by concrete blocks thrown round them. The girders were of the parallel flange type. The lattice-bars formed two series of triangles, inclined at 45°. The superstructure was designed to carry a footpath on the lower flange, and an asphalt cart roadway, flush with the railway, on the top. The cross-girders carrying the railway were suspended in stirrups from the upper flange. The first operation was the erection of a temporary wooden trestle bridge, which was occasionally much damaged by floods, but was easily repaired. It served for material trains for four years. The bricks for the foundation cylinders were of three special forms. The lime was slightly hydraulic, and was made of the kunkur of the district. The mortar was composed of equal volumes of lime, brick-dust, and fine river sand. The concrete was made of broken waste brick and 42 per cent. of unground mortar. The excavation of the cylinders was effected principally by Bull's dredgers. Cylinders of brick, 12½ ft. in diameter and of the same height, were sunk from 10 ft. to 12 ft.; then a similar length was added and sunk; next a length of 25 ft. was added, and sunk usually without weighting. Finally a length of 20 ft. was built, completing the 70 ft., which was sunk sometimes to 60 ft., when a load of 150 tons of rails commonly sufficed to complete the sinking. Among the tools used for excavating the material from the interior of the cylinders, Fouracres' "spider" proved efficient. Whenever a cylinder showed a tendency to leave the perpendicular, it was corrected by shoring from the ground, and by passing a chain round, the two ends of which were anchored taut at a distance. Rails laid across the chain produced an efficient horizontal pull. The average progress with the large cylinders was 2 ft. a day of actual sinking. Half the girders were put together on the south bank and half on the north, and they were carried into place by two traveling gantry cranes. The floating of the girders for the spans over the main channel of the river was accomplished by four native barges, on which timber staging was erected.

THE ALEXANDRA BRIDGE.

The Alexandra Bridge was 9,300 ft. long and 100 ft. deep. The first brick was laid on the 1st of November, 1871. The first train crossed the bridge on the 23d December, 1875, and it was opened on the 27th of January, 1876. In floods, the Chenab rose 11 ft. above low-water mark, and its width at Wuzerabad was three and a half miles. The mass of the water did not flow rapidly; but the main stream, corresponding to the fluctuating deep channel, rushed through with great velocity, in a serpentine direction. This was often nearly at right angles to the general course of the river when obstacles occurred. Under these circumstances the bed was driven before it. The depth of the main current was more than 50 ft., moving at a rate exceeding ten miles an hour. The ground for about half the space of three and a half miles between the banks was composed of river deposit. On this a massive embankment had been raised for several years to carry the Grand Trunk Road as far as possible across the river-bed, the rest of the way being over temporary bridges of boats at the varying channels. During four months a ferry was established. A back channel, called the Pulkoo Nullah, flowed for several miles parallel to the main river, and in high floods their united waters submerged the intervening country. The effect of the embankment was to dam up the body of comparatively still water forming the bulk of the river, and to divert the swift moving diagonal current against the crumbling shores. Hence the Pulkoo developed into a deep navigable channel 800 ft. wide. At Kuthola, on the northern shore of the Chenab, the river became wider by half a mile. The main current set against the proposed site of the northern abutment of the bridge, and the deepest water was close under the nearly vertical bank. The Trunk Road was gradually falling into the river, and a ferry had to be established at the Pulkoo. Thus, in the Wuzerabad Reach, the Chenab had become wide to an abnormal extent. The fine sand of the bed was ascertained to be about 65 ft. in depth, overlying clay of moderate consistency. The rapid current, moving from shore to shore, was likely not merely to attack the bridge piers in flank, but also to scour the ground from under them. Various works were undertaken to improve the site of the bridge. The first was to close the Wuzerabad navigable channel by an embankment three-quarters of a mile long. A second embankment extended from the southern abutment of the bridge to the Pulkoo Nullah to prevent the water of the river pouring into the Wuzerabad channel during flood. A third work deflected the stream at right angles to the general alignment of the railway in a direct line through the bridge. A fourth main work, being a star-shaped spur of trees and stones, was to prevent the river cutting behind the abutments in the event of disaster to the up-stream works. Several subsidiary works were executed of rough tree-spurs to catch floating sand, and to assist in turning the stream toward the center of the river. The Chenab training works were carried out by September, 1872, at a cost of 4½ lakhs of rupees, and had since been maintained at a yearly cost of ½ lakh of rupees. The first design for the bridge was that it should consist of single well-piers, 12½ ft. in external diameter, sunk 40 ft., and carrying lattice-girders under the rails, 97½ ft. in length from center to center of the piers. But the high floods of the rainy season of 1871 led to the adoption of Power's three-well system, and to the wells being sunk 70 ft. The piers were 35 ft. long, 8 ft. 8 ins. thick, with semi-circular ends, standing on similar basements 38 ft. long, supported on diminishing arches between the wells. Three were to be sunk 6 ins. apart. The abutments were on fifteen wells, sunk to the same depth as the piers, and in two rows parallel to the central line. This change increased the quantity of brickwork originally proposed five or six times. At the close of the rainy season of 1871 the curbs of several of the piers were pitched. It was then determined to adopt Warren girders and to have the rail level at the bottom; also to have sixty-four spans, 142 ft. from center to center, and the bridge was thus commenced. The bridge over the Pulkoo back channel consisted of nine spans, 43½ ft. from center to center, with pairs of single well cylinders sunk into the clay substratum underlying the river bed. The girders were of plate iron, carrying the rails on the top. On account of the great length of the Chenab Bridge, two passing places were provided by widening the structure for two spans and making it stronger. The remainder of the paper was occupied with an account of the setting out of the bridge, of preparing the curbs for the wells, of building and sinking the wells, and the dredging operations, and of placing a protection of stones or concrete blocks round the piers. With a view to assist the piers to resist side currents, no provision was made for the expansion of the girders in every second span, so that the piers were tied together in pairs by fixed bearings. During the flood season of 1873–74 a serious accident occurred. A great mass of protective material had been placed round the finished piers, presenting the appearance of a weir across the river; but owing to the want of sufficient weights the work was not completed at the newest wells before all were submerged. A concatenation of causes led to the current of the river running parallel with the bridge. Ultimately a deep trench was scoured out along the face of the bridge for more than a mile in length, resulting in the up-stream and center wells of three of the piers toppling over from insufficiency of base. As the sites of three piers were blocked, so that fresh wells could not be sunk at the same place, two of the spans of the bridge were modified to suit the altered circumstances. The total cost of the bridge, including the training works, was 65 lakhs of rupees.

THE JHELUM BRIDGE.

The Jhelum Bridge was situated on the line of the Grand Trunk Road, the river being about 5,000 ft. wide. The bed was of sand, 15 ft. to 20 ft. deep, overlying a thick stratum of bowlders and shingle. The fall of the bed was 1 ft. per mile, and the approximate discharge of the river at high flood was 200,000 cubic feet per second, the maximum recorded surface-velocity being 8·66 ft. per second. The length of the bridge was 4,875 ft. between the abutments, with training works on the left bank. There were fifty spans of 90 ft. each, giving forty-nine piers and two abutments. The right abutment and the three contiguous piers were founded in a stratum of clay; all the above piers were founded on the bowlder stratum. The foundations were brick cylinders, three in a line transverse to the bridge, a center one, 12½ ft. in external diameter, and two flanking ones, each 10 ft. in diameter. The brickwork was built on a substantial wrought-iron curb, to which it was bonded by circular flat iron rings and vertical round iron tie-rods. Three rings were introduced in the 32 ft. length of brickwork, at intervals of 10 ft., and the tie-rods, starting from the curb, went through the whole length of brickwork in the well. In the smaller wells there were eight rods and nine in the larger wells. The rings were of flat iron, 3 ft. broad by $\frac{5}{16}$ in.

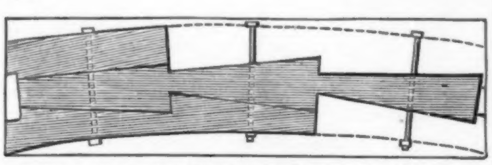
thick. The brickwork of the smaller wells was 2 ft. thick; that of the larger wells was 3½ ft. thick. It was composed of specially made radiating bricks, set in mortar, consisting of one part of stone lime, two parts of kunkur, and six parts of fine brick-dust, the whole well ground together. The wells were successfully sunk through artificial islands. They were filled with concrete and connected by small arches. The superstructure of the piers was 27½ ft. long, 7½ ft. wide, with semi-circular cutwaters. They were carried up 21 ft. above low water. The abutments were founded on three wells, each 12½ ft. in diameter, and were similar to the piers, but flanked with longitudinal wing walls. Nearly nine wells were sunk per mouth. A spur of earth and bowlders, 4,800 ft. in length, was made from the left abutment of the bridge to the high ground forming the left bank of the river, as a protection against the river getting in rear of the bridge abutment. Moreover, an average amount of 13,467 cubic feet of bowlders had been thrown round each of the piers. The bowlders formed a local supply of material ready to be dropped into any holes scoured out around the piers, and gave support to the piers to resist the overturning action of the stream. The superstructure was composed of a pair of lattice-girders, connected on the top by an upper roadway of cross-girders and rail-bearers, covered by buckle and flat plates, braced on their under sides. This upper roadway carried the railway and two footways. There was a lower roadway for foot passengers and mules and ponies only. A detailed account was given of the girders and roadways and of the erection of the girders. The total cost of the bridge, including the protective works, had been £139,502, or £28 11s. per lineal foot.

CURVED BEAMS.

ON Trajan's column, at Rome, has stood since A. D. 114 the sculptured representation of that Emperor's bridge over the Danube, which (like the construction of the column itself) dwarfs modern efforts, with few exceptions, by its colossal nature. The bridge was 3,000 ft. in length, and had twenty-two arches of timber, so that it is not going far aside to allude to it in a notice of curved beams.

They are of four classes or systems of formation, namely, the scarfed, the bent, the flitched, and the laminated. The first consists in making a curved beam out of straight logs, and is probably an ancient plan, of which the use has been occasional during a long period, or, if sometimes forgotten, as frequently revived. Palladio used such beams, and may have received the idea from the sculptured record on Trajan's column. About a century ago the Brothers Grubenman, of Switzerland, were famous, and the arched ribs used by one of them in a bridge at Wettenghen were of formidable dimensions. The space being 230 ft., the beams were composed of seven logs in depth, with serrated tabulations throughout the length, so that the camber could be obtained without any actual bending of the wood. The heading joints in each layer were 12 ft. apart, but so arranged as to form an interlacing bond, and the whole was strongly keyed and bolted. It was ligneous masonry.

The following account, "published under the superintendence of the Society for the Diffusion of Useful Knowledge," is too remarkable an instance of the difficulty encountered by ordinary literati in describing technical affairs to be neglected:



STRAIGHT LOGS CURVED IN THE TABLING.

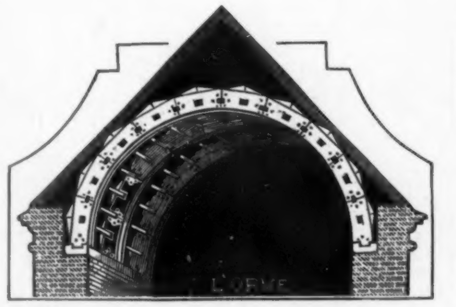
"The abutments were 25 ft. high, and the arch between them was a catenary—that is, the same form which a rope or flexible chain assumes by its own weight when hung over two fixed pegs. This arch was, of course, inverted in the same manner as the iron chain bridges that have lately been constructed in this country, and, making allowances for the difference of materials and the mode of junction, it may be fair perhaps to consider it as the first chain bridge that ever was constructed in Europe."

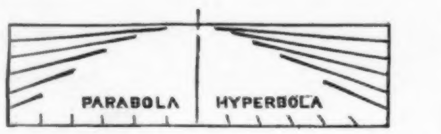
Misled by the idea of a catena, the writer failed to reflect that it would be as difficult to suspend an arch of timber convex downward as to erect a flexible chain of iron, convex upward. My illustration is not drawn from a particular example, but is intended to represent the serrated tubing referred to, and which was attended with a waste of material, equal to one-third of the total quantity consumed. The large volumes of Krafft and Emy afford more express and extended information on this bold and powerful form of combination than I can propose to present.

The second class began early in the present century, when M. Wiebeking, an able German constructor, effected an important improvement. He contrived to bend to the requisite curvature timbers as large as 15 ins. square and 50 ft. long, thus reducing the number of heading-joints and the waste generally attendant on short pieces. For when the grain could be forced into the direction of the curve, the great labor of the serratures and the loss of material they occasioned could be at once avoided. The qualities of economy and grace were thus added to the masculine character of earlier work. With the same artist also originated the practice of increasing the depth by additional logs as the beam receded from the crown—an expedient that has been fully approved by science and experience. Mr. Herman Haupt, A. M., of New York, for instance, who, from his knowledge of American examples, is well entitled to speak, says "the lightest and most simple system, and the one best calculated to attain the maximum limits of span, consists in a solid beam of parabolic curvature, increasing in depth from the vertex to the ends."

A figure will be given in the next chapter, but nothing could more exactly illustrate this description than the beams employed by Mr. Wiebeking in the bridge at Bamberg in 1809. The span is 208 ft., and the rise 17 ft. The beams are three logs in depth at the crown, and five at the springing, keys being introduced in the longitudinal joints to prevent sliding. Beams compacted on this plan of bending the fibers are probably more vibratory than where the parts are cut to the requisite shape, according to the old rule, and this property must increase with the length in either case. There are several American examples of more than 300 ft., and that of Grubenman over the Linnant, at Wettenghen, was 390 ft. The components may, in fact, be multiplied to any extent, and the crushing point of the material marks their only limit. But when beams of enormous dimensions, and exposed to the disturbance of moving loads, are supported by stone abutments, the most careful provision ought to be made, lest they crush the mortar and fracture the masonry. Æsthetics have a higher standard now than at the beginning of the age, and when beams constitute the leading elements of structures, it seems only fitting that their forms should be displayed. Casing has no greatly preservative effect, and when made to imitate stonework, degenerates into an unworthy deception. The carpenter owes some devotion to his proper material, and it affords an ample range for his ability. If less monumental than stone, it is oftener available, and he who might almost span the Thames in a single bow may well leave to the Arno and to Florence, unpirated, the moderate yet many-centered elliptics of Sa. Trinità.

With regard to the third class, or flitch beams, exact information exists. It was the invention of a French architect of the first celebrity, the contemporary of Palladio. He traveled in Italy, probably visited the great Vicentine, and studied his works. Returning to France, L'Orme soon acquired especial *éclat* from this constructive novelty. "We have no further need," said he, "of great trees for the beams





and rafters of our roofs, for they may be formed of ribs that will seem to grow out of the walls." His mode was this: Stopping the inner portion of the wall at some distance below the eaves, he placed on the bed thus formed a strong wall plate, with mortises at proper distances. At these intervals he raised ribs constructed of two thicknesses of boards of equal lengths and breadths, but commencing with a half length on one side, so as to make the abutting joints alternate. These boards being pinned and keyed together formed a rib of considerable stiffness, and commonly of semicircular shape. Supplementary ribs were added at the eaves and apex when requisite. Three boards were sometimes joined, and the strength proportionally augmented. It was no ephemeral contrivance, to be laid aside as soon as novelty was over, but one that has maintained a permanent place in the carpenter's repertory. In proof of this, it is only necessary to instance their use by Mr. Decimus Burton, in the dome of the Colosseum, so long a striking feature of the Regent's Park, but recently taken down. They appear also at frequent intervals in the temporary erections for exhibitions, and other works of great capacity, where the effect is occasionally enhanced by transverse members of ornamental character. The facility with which any form of arch, pointed or otherwise, can be produced, is a prominent merit of the flitch method.

Mr. Price, in his "British Carpenter," recommended curved beams on the flitch principle for bridges; but that is an application for which they are ill-suited. Neither the headings nor the lateral cohesion can be regarded as trustworthy under a strain of much severity; though for carrying a light load, such as temporary roofing and skylights, over a large space, these beams are eminently convenient. Mr. Price was not the first to conceive them, nor was any British carpenter. They are due to the eminent Frenchman above named, and in L'Orme's "Nouvelles Inventions pour Bien Bastir," A. D. 1561, are to be found, in addition to very numerous exemplifications of the kind, indications of arches made by two thicknesses of boarding, bent concentrically on the flat.

Whether through the survival of this suggestion, or the natural development of Wiebeking's system, modern constructors have produced beams perfectly distinctive in character and name from the whole-timber and the flitch classes. This fourth sort, being compacted of thin planks or boards, are called "laminated," and are described in the "Nouveau Système d'Arcs pour les Grandes Charpentes, par A. R. Emy, Paris, 1828." They were introduced here in railway bridges by Messrs. Green, of Newcastle, in 1837. The example best known in London, however, and probably the neatest anywhere produced, was that by Mr. Lewis Cubitt, at the terminus of the Great Northern Railway, King's-cross. The station, 105 ft. in width, was spanned by semicircular ribs, 11 ins. wide and 12 ins. deep, made of nine thicknesses, and moulded at the angles. On the haunches next the walls were open spandrels of iron, and there were extra laminations of wood at the crown, 9 ins. wide and 12 ins deep. The distance between the principals was 20 ft., and their simple figure and accompaniments produced a remarkable impression of strength, lightness, and economy. They are represented in the later editions of Tredgold's "Carpentry," "Gwilt's Cyclopædia," and "Weale's Rudimentary Series" (the "Art of Building"). Unfortunately, the confined hot vapor from the engines proved destructive, and the wood has been replaced by iron substitutes.

These several methods offer to the modern carpenter a great choice of means, of which he can avail himself according to the nature and conditions of his works, but in all I would again venture to suggest the use of iron screws, of which the thread should cross the joint and draw the surfaces forcibly together. Having at the same time an eye to the possible effect of shrinkage, it may be judicious to connect only two thicknesses with the same screw.—*Building News.*

KEIR EXPLOSIONS.

By WILLIAM NANSON, Bondsville, Mass.

A FEELING appears to be prevalent among bleach and print works managers that the use of high pressure or Barlow keirs is unsafe, on account of their liability to explode. The danger, I think, is overestimated, for if we examine carefully into the probable causes that have led to such explosions, we shall find that they are easily avoidable, and, therefore, that it is incorrect to assume that high pressure keirs must be dangerous at all times and under all circumstances. But it is nevertheless true that high pressure keirs have exploded, with all the disastrous effects incident to a steam boiler explosion, and therefore I shall endeavor to show in the present paper the causes which may lead to the generation of forces sufficient to explode a keir, how these forces may be liberated into activity, and how the generation of such forces may be avoided and all danger of explosion effectually prevented. By way of illustration, I shall take the case of a keir that burst at the print works of the Messrs. Prokeroff, at Moscow, Russia.

The keirs in question were 11 ft. 6 ins long and 6 ft. 6 ins. diameter, made of $\frac{5}{16}$ in. iron; the joints were single fished butt joints, running in the direction of the length of the keir. These joints were single riveted with $\frac{5}{8}$ in. rivets, the rivet heads inside the keir being countersunk. Each keir was furnished with a steam gauge, back pressure valve, and a 3-inch safety pipe set to blow off at a pressure of 50 pounds per square inch.

Being at the works myself shortly after the explosion took place, I was enabled to examine the various parts of the broken keir, and also to make minute inquiries regarding all the attendant circumstances.

An examination of the torn edges of the plates showed the iron to be in good condition, strong, and fibrous, and subsequent tests proved it to possess an ultimate cohesive power equal to about 50,000 pounds per square inch section. Now if we take one-third of this as being the *permanent* tensile strain the iron would bear without injury, and find the steam pressure equivalent to such a strain, it would show us that the keir could be worked at a pressure of 133 pounds per square inch with safety, and that we should have to reach a pressure of 212 pounds per square inch to burst the keir. It must be understood that such a pressure of steam could not exist, because in the safety valve we have an outlet 3 inches in diameter which would relieve the pressure whenever it exceeded 50 pounds per square inch, and the boilers which supplied the keirs with steam were never worked at a pressure of over 55 pounds per square inch, hence it will be safe to infer that over-pressure of steam could not be the cause of the explosion.

If we take into consideration the fact of the joints all running in a line with the weakest portions of the keir, viz., in the direction of its greatest length, and the loss of binding force in the rivets by countersinking, and the probable shearing strength of single rivets subjected to such a direct strain, it will be at once seen that the joints were by far the weakest portions of the keir, and we can easily come to the conclusion that if the pressure which burst the keir had been a gradually accumulative one, it would have torn the plates asunder at the line of rivets. I found, however, that the lines of fracture ran in all directions. They did not radiate from any given point, neither did they run with or even parallel to the lines of rivets, but, on the contrary, in all cases where the lines of fracture had intersected the lines of rivets the fish plates had offered no perceptible opposing force, but were torn across in the direct lines of fracture. It should also be borne in mind that the ease with which a 3-inch safety pipe would relieve any over-pressure renders inadmissible the theory of any *gradual* accumulation of pressure either from steam or other causes; therefore I think it will be safe to conclude—first, that the keirs were in good condition, and well able to withstand any *steam* pressure which it was calculated they should bear; second, that the keir was not exploded by steam pressure; and third, that whatever forces were generated to cause the explosion must have been brought into activity instantaneously. Hence, in order to establish any theory regarding the explosion based upon any supporting evidence, it will be necessary for us to look to other causes than steam pressure, wear and tear, or imperfections in the construction of the keirs.

The keirs in question exploded during the process of "bowking," or while the goods were being boiled in a liquor composed of 800 gallons of water, 360 pounds of soda ash, and 150 pounds of resin, the soda being almost a pure carbonate. Any elementary work on chemistry will tell us that carbonic acid is liberated from its compounds by any acid stronger than itself, and that it is the weakest of all acids. Therefore it will be readily understood that the presence in the keir of any substance having a decided acid reaction would decompose the carbonate of soda and set the carbonic acid free, and it is to this process of liberation that we may trace the first elements of danger. There are several ways by which we can account for the presence of sufficient acid in the keir to liberate the carbonic acid gas from its base. In the first place, the goods may not have been thoroughly washed after the previous operation of "souring," and a large quantity of free acid may in this manner have passed into the keir with the goods. Another and more probable theory is that the decomposition of the carbonate of soda and consequent liberation of the carbonic acid was due to the action of the resin, as it is known that resin contains two compounds having a strong acid reaction, and each capable of displacing carbonic acid.

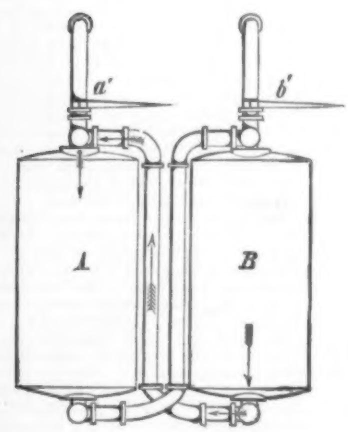
It is a recognized fact that when resin and soda are boiled together in the ordinary manner very little chemical change takes place; the action is almost wholly a mechanical one, the particles of resin being merely held in suspension in the liquor, although it is certain that sufficient chemical action does take place to cause the evolution of a portion of the carbonic acid, and should the liquor be violently agitated or raised to a higher temperature, the evolition of the gas increases directly as the increase of the heat. There is no doubt that at a temperature such as would exist in a high pressure keir the resin would be acted upon more energetically, and it is possible that a temperature might be finally reached at which the hydrocarbon constituents of the resin might become partially or wholly volatilized, and the acids combined with them be thus liberated into powerful action. The result would be the energetic decomposition of the carbonate of soda, and the consequent generation of a large volume of carbonic acid gas. If we take into consideration

the limited room for expansion in a keir more than two-thirds full of cloth and liquor, working at a pressure of 45 pounds per square inch, and increase this pressure by bringing into active force the carbonic acid gas contained in 360 pounds of carbonate of soda, we should create a pressure far above the bursting point of the keir, because it must be borne in mind that the increased strain would be an impulsive one, being produced instantaneously, and that all impulsive strains are equal in force to double the same load laid on gradually.

I have already shown that the safety valves and other conditions of the case preclude the possibility of a *gradual* accumulation of pressure either by gas or other causes, therefore it is necessary to show *how* the gas can be liberated into activity instantaneously. There are two methods by which this might be accomplished—first, by the generation of a certain degree of heat sufficient to suddenly decompose all the chemical compounds in the keir, and which is hardly probable; and secondly, by the sudden removal of the pressure.

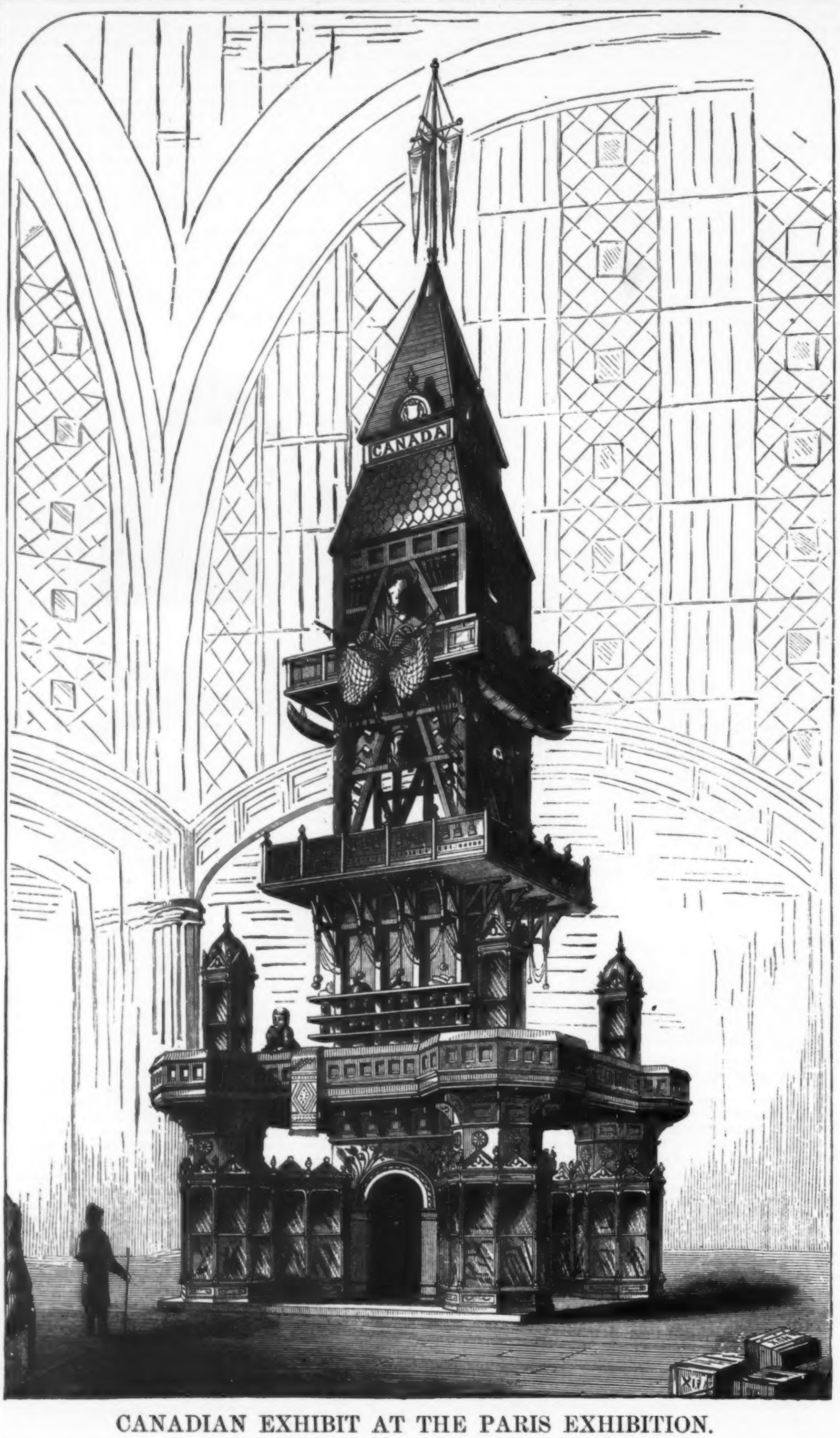
Carbonic acid gas is easily soluble in water even at the ordinary pressure of the atmosphere, and it becomes more soluble as the pressure is increased. Even the gas itself may be compressed into a fluid state, and if the pressure be removed the gas is immediately liberated and expands to its normal condition. (This can be illustrated by loosening the cork from a bottle of soda water.) If, therefore, we mix the gas with water at a pressure of *three* atmospheres, such as would exist in the keir, a large volume of it would be taken up by the liquor, and remain in a quiescent condition until a removal of the pressure, when it would be suddenly liberated and expand into forcible action. Hence, though the action of the resin may be producing a continually increasing volume of carbonic acid gas, the gas may be taken up and remain combined with the water until a favorable moment arrives for its liberation, and there is little doubt that the most favorable opportunity for this to occur would be a sudden reduction of the pressure.

This reduction might be effected by either of the following causes—first, by the sudden condensation of the steam in the upper portion of the keir, and the consequent conversion of the whole of the liquor into steam and carbonic acid gas. This, of course, could only occur through gross carelessness, such as directing a stream of cold water on the outside of the keir, which I have known to be done for the purpose of washing off the lime and other impurities. The other and most probable theory is that the attendant, in changing the liquor from the full keir to the empty one, waited too long before opening his liquor valve, and thus allowed the pressure in the empty keir to become much lower than the pressure in the keir upon which the steam was acting and which contained the liquor. Consequently the sudden opening of the valve and instantaneous liberation of the pressure caused the violent evolution of the carbonic acid gas simultaneously with the forcible entry of the steam and liquor. Of course it must be understood that both keirs were full of cloth, and that in speaking of the empty keir I mean the one in which there was no liquor. The following diagram will illustrate my meaning more fully:



Supposing these keirs to be full of cloth, and to have been working about four hours, and the steam to be entering at the valve, *a'*, in the keir A, and the liquor to be all over in the keir B; the attendant, in changing the liquor back into the keir A, would turn off the steam at *a'*, and turn it on at *b'*, and, after waiting a few moments to allow the pressure to increase in the keir B, to be greater than that in the keir A, he would open the valve *a'*, to allow the liquor to pass from B to A, as indicated by the course of the arrows. Under all ordinary circumstances, if the pressure in the keir B was 45 pounds, the pressure in the keir A would be about 35 pounds, the difference between the keir carrying the steam and the keir receiving the liquor being usually about 10 pounds; hence we see that under ordinary circumstances the actual pressure removed in changing over the liquor is only 10 pounds; but if the attendant wait too long before opening the valve *a'* to let the liquor into A, the pressure in A becomes rapidly diminished by condensation, and it might be possible for him to neglect it for a sufficient length of time to reduce it to the ordinary pressure of the atmosphere, and of course as we diminish the pressure in the keir A we diminish the force opposed to the liberation of the gas when the valve *a'* is opened to admit the liquor. The probability of this theory is strengthened by the fact that the keir did explode a few moments after the attendant had opened the valve *a'*, and all the other keir explosions that have come to my knowledge have occurred under precisely similar conditions; therefore I think it will be safe to infer that keir explosions may be attributed to the generation of carbonic acid gas, that the carbonic acid must be brought into active force instantaneously, and that its sudden liberation is due to either the presence of a high degree of temperature sufficient to suddenly decompose all the chemical compounds in the keir, or to the sudden removal of the pressure, the weight of evidence being decidedly in favor of the latter theory.

Now at a dye works, where no resin is used in boiling, there is no danger, and no explosions have ever been known to occur; but at a print works, where the use of resin is necessary, all danger can be effectually prevented by using the soda in a caustic state. Caustic soda contains no carbonic acid, therefore none can be liberated; and with a full knowledge of these facts before us, I should unhesitatingly say that, if there is no fault in the construction, there is no more danger in a high pressure keir than there is in an ordinary wooden keir with an open top.



CANADIAN EXHIBIT AT THE PARIS EXHIBITION.

THE PARIS EXHIBITION.

France occupies a larger amount of space than all the other countries combined. The palace of the Trocadéro will, it is true, be partly occupied by certain foreign contributions, but it is essentially a French portion of the Exhibition. With the exception of the pavilions of China, Japan, Tunis, Persia, Norway, and Sweden, and one or two others, all the buildings in the Trocadéro grounds are French. The principal annex is the Algerian Palace, a noble structure in which are collected the various exhibits of the colony. The exhibits of railway material, civil engineering, forest products, and constructive material, the two great pumping stations, and a variety of conservatories, complete practically the list of structures on this side of the Seine. The greatest pains have been taken to develop to the utmost the garden space available, for in the Champ de Mars the ground is so crowded with annexes as to leave little opportunity for picturesque effect. In the Main Exhibition Building of the Champ de Mars, France occupies the whole of one side, the vestibule opposite the Ecole Militaire, and one half of the vestibule facing the Seine. Outside the main building there are five French boiler-houses; the two grand French annexes for machinery, with the Bureaux d'Administration between them; the annex for life-saving appliances, pumping machinery, and ports and commerce, facing the Seine, while a multitude of small buildings for French exhibits crowd the grounds. In the center of the Champ de Mars is the magnificent building of the Ville de Paris, in which France occupies the largest space in the galleries of the Fine Arts.

Next in importance comes England, occupying the post of honor, not only of the building, but sharing with France half of the Grand Vestibule, which will be worthily occupied by the Indian trophies of the President Prince of the British Commission and the exhibits of our great Eastern Empire. The Australian colonies and Canada fill the corner pavilion, and Canada has raised in the center the beautiful trophy of which we publish an engraving. This trophy, 100 feet in height, is an exhibit of all the useful timbers in the Dominion, and of slate and other building materials. Its galleries, moreover, are utilized for the display of general objects. Canada has, moreover, a large space in the industrial sections, and an annex in the grounds, as well as the building constructed by Messrs. Cubitt, and generously given to the use of the Dominion at the suggestion of the Prince of Wales.

The British exhibits will not be unworthy of the country and its colonies; and though we may perhaps naturally forget the importance of the collections of other nations, we cannot avoid the conviction that the position allotted to Great Britain represents fairly the part she plays in this Exhibition. As for annexes, we have the long agricultural shed, well adapted for the purpose of display, but not ornamental;

there are besides two or three small annexes, and a court in the Fine Arts Gallery.

The United States of North America are adjacent to England. Coming very late in the field, a place of honor has nevertheless been reserved to them, and one which will be well filled despite the shortness of time at the disposition of exhibitors. The United States Agricultural Building is an extension of that of Great Britain. Belgium and Austria both have very important allotments, and we imagine that the exhibits of Belgium and Switzerland will rank next in importance to those of France and England. Both countries, standing in the first industrial rank, have shown great enterprise in taking so large a part in the Exhibition, especially in the section devoted to machinery.

Italy has a large area, and though it is too much to expect that when the exhibits of this country are finally arranged they will display much of high value in the mechanical arts, they have spared no pains to take a foremost place in other industries. Of Sweden and Norway there is no need to speak. What they did at Vienna and Philadelphia is a guarantee of their collections now. Spain, too, is largely interested, and China and Japan are now known at exhibitions as very important contributors. Holland, Portugal, Denmark, South America, all the countries, in short, are here, and all have done their utmost to crown this great triumph of French energy and power. That is, all but Germany, who, unfortunately for the rest of the world, and we believe for herself, declined to participate. True she shows some pictures, but we may look in vain for the display which was conspicuous at Vienna. Germany's decision was, however, fortunate in some respects for other countries, since had she elected to be present, room for her must have been made at the expense of others.

By the system of classification adopted, the contents of the Exhibition are divided into nine groups, subdivided into ninety classes.

THE NEW METAL GALLIUM.

THE metal gallium, which is the latest discovery among the recognized elements, was first seen by M. Lecoq de Boisbaudran in the autumn of the year 1875, and so named by him in honor of the land of its discovery, France. Like its four predecessors made known within the last 20 years, gallium was discovered by the process of spectrum analysis, applied in this instance in a special manner contrived by the ingenuity of M. de Boisbaudran himself, long eminent as a spectroscopist. The spectrum of gallium is characterized by two marked violet lines, the less refrangible of them being especially brilliant. Hitherto the new metal has been recognized only in certain varieties of zinc blende, that of Pierrefitte in the Pyrenees having furnished the chief portion of gallium hitherto obtained from any source whatever—nearly half a ton of this ore having been employed by M. de Boisbaudran to furnish the dozen grains or so of metal wherewith he has been able to establish the leading properties of the element. In its appearance gallium manifests a general resemblance to lead, but is not so blue-tinted or quite so soft, though it is readily malleable, flexible, and capable of being cut with a knife. Like lead again, and unlike zinc, gallium is not an easily volatile metal. Unlike lead, however, it acquires only a very slight tarnish on exposure to moist air, and undergoes scarcely any calcination at a red heat. The specific gravity of gallium is a little under 6, that of aluminum being 2·6, that of zinc 7·1, and that of lead 11·4. A most remarkable property of gallium is its low melting point. It liquefies completely at 86° Fah., or below the heat of the hand; and, still more curiously, when once melted at this temperature, it may be cooled down even to the freezing point of water without solidifying, and may be kept unchanged in the liquid state for months. Indeed, in the original communication of its discovery to the French Academy, it was described as a new liquid metal, similar to mercury; but on touching with a fragment of solid gallium a portion of the liquid metal in this state of so-called superfusion it at once solidifies. Unlike lead, again, gallium is a highly crystalline metal, its form being that of a square octahedron. In its chemical habitudes the rare element gallium shows the greatest analogy to the abundant element aluminum. In particular it forms a sort of alum not to be distinguished in its appearance from ordinary alum, but containing oxide of gallium instead of oxide of aluminum or alumina.

But the chief interest of gallium, from a scientific point of view, is connected with the history of its discovery. All previously known elements have been discovered, so to speak, accidentally, and their properties have been not in any way foreseen, but rather met with as subjects of surprise; but the blende of Pierrefitte was deliberately taken up for examination by M. Lecoq de Boisbaudran in the expectation of finding a new element. The existence of an element having the characteristic properties of gallium was, moreover, upon entirely different grounds, predicted very definitely by a Russian chemist, M. Mendelejeff, in 1871, and in a more general way several years earlier by an English chemist, Mr. Newlands. This double prediction was based on a study of the relations of the known atomic numbers of the elements. These numbers have only lately been perceived to form a tolerably continuous seriation, which, again, is associated in a remarkable manner with the seriation in properties of the elements themselves. In the series of numbers, however, certain terms are here and there missing, and in particular a number was missing which should belong to an element having properties intermediate between those of aluminum and iridium. What these properties would be was predicted in most minute detail by M. Mendelejeff in 1871. He predicted, for example, that the specific gravity of the missing metal would prove to be about 5·9. Operating on very small quantities, M. de Boisbaudran, in the first instance, found the specific gravity of gallium to be 4·7; but on repeating his determination in 1876, with special precautions and on a somewhat larger though still very small scale, he found it to be exactly 5·935, certainly a most remarkable fulfillment of the prediction with regard to it.

In a recent number of *La Nature*, M. G. Tissandier gave the following account of the extraction of a quantity of gallium by M. de Boisbaudran, accompanied by a description of some of its properties:—Without shrinking from the delicate and frequently troublesome operations necessary in treating a mass of blende weighing 4,300 kilogrammes, he has succeeded, in collaboration with M. E. Jungfleisch, in getting out 62 grammes of gallium. "If," say these gentlemen, "we take account of inevitable losses and of a few grains of gallium remaining in the various products of our operations, we may estimate the proportion of gallium in Bensberg blende at about one part in sixty thousand, or 16 milligrammes per kilogramme. The small proportion of matter to extract will sufficiently explain the large amount of time consumed in its extraction."

The preliminary operations were carried out at the works at Javel belonging to M. Léon Thomas, a successful manufacturer as well as patron and student of science. The 4,300 kilogrammes of blende were concentrated in a mass weighing about 100 kilos., containing the whole of the gallium. From Javel this mass of concentrated stuff was transported to the laboratory of M. Lecoq de Boisbaudran at Cognac, and, after further concentration, was purified and reduced to a metallic condition at the Ecole de Pharmacie, at Paris. After a long succession of attacks by acids and alternative precipitations, the metals associated with gallium, such as zinc, iron, cadmium, iridium, &c., were eliminated. The gallium in the residue of the solutions from which the other metals had been separated was got in the metallic condition by the action of the electric current.

"The deposition of metallic gallium," say Messrs. Lecoq de Boisbaudran and Jungfleisch, "is only carried out successfully under certain special conditions. The intensity of the electric current, for instance, should vary with the state of the solution, but the surface of the negative electrode should always be small, relatively to that of the positive electrode. In one of our operations, by which we got 8 grammes of gallium in twenty-four hours, forty Bunsen cells (18 centimeters high), ranged in eight parallel rows, each of five cells in tension, acted on a negative electrode, the double surface of which did not exceed 15 square centimeters, while the positive electrode had a development of about 450 square centimeters. The metal on being thrown down cold frequently forms long threads of crystals which take on the appearance of needles, fixed normally to the electrode by one of their extremities; some few have reached the length of 3 centimeters. Above 30° the metal runs in drops, which coalesce at the foot of the electrode." Crystals of gallium were presented on behalf of the operators to the Academy of Sciences by M. Berthelot, in its sitting of February 18th. These crystals, which have a distinct grayish-blue metallic luster, belong distinctly to the octahedric system, but their angles have not yet been measured, their faces being slightly rounded. They are mounted on small glass stems, and kept under a glass globe from the contact of the air.

Crystallization was effected by introducing a platinum wire carrying a particle of solid gallium into the metal cooled to 10° or 15° C. below its melting point. After the lapse of a very short period, varying from 3 to 10 seconds, octahedric crystals show themselves, very slightly modified at their summits by traces of their base. The crystals were shown in the accompanying drawings of the full natural size. If the crystals are not promptly withdrawn as soon as formed, the metal reacquires part of its lost heat, solidification slackens and the base enlarges.

Gallium is a hard and malleable metal; it takes under the hammer the polish of the anvil, but rapidly grows harder and brittle, and is then liable to fly to pieces. In spite of its relatively considerable hardness, gallium leaves on paper strongly defined marks of a bluish-gray color. It retains its luster in the atmosphere of a laboratory constantly loaded with acid vapors, and undergoes no alteration in appearance in boiled water. In aërated water it tarnishes slightly.

Gallium, which melts at 30°, may be kept superfused in a tube hermetically sealed. MM. Boisbaudran and Jungfleisch have prepared a certain quantity of it in this condition. It remains fluid like mercury, and when the tube is inverted it creeps along the glass like melted wax. In a liquid condition, gallium has the brilliant whiteness of tin or silver. It would be of great value for the determination of temperatures rising to 300° or 400° C., but its habit of clinging to the sides of the glass vessel in which it may be contained constitutes at present an impediment in the way of its being used for thermometric purposes. It is possible that some means may be found for correcting this tendency, and that the new metal may thus be made capable of receiving various applications in the domain of experimental science.

Gallium leaf has also been prepared by running the melted metal between heated glass surfaces. On cooling, especially if the cooling is carried out under water, the metal is easily detached from the glass. This specimen melts in the hand: it retains its characteristic dull blue metallic reflection. A small bar has also been cast, the elasticity and malleability of which are easily demonstrable.

Crystallized gallium prepared cold by electrolysis of a potassic solution decrepitates on being thrown into hot water, and gives rise to bubbles of gas. "By electrolysis of a liquor heated up to 30° C.," say the experimenters, "we have often obtained, especially toward the end of the operation, a puffy metallic mass swelling in warm water, and having the aspect of an ammonium amalgam. Kneaded in water at 40° C., this mass contracts and is finally resolved into ordinary fluid gallium.

Some new compounds of gallium, comprising the chloride, bromide, and anhydric iodide, have been presented to the Academy. Chlorine attacks gallium in the cold state very actively, with an abundant disengagement of heat. The product is faintly yellow; it would probably be perfectly colorless if pure. It is well crystallized, very fusible, easily becomes volatile, and imbibes the ordinary moisture of the atmosphere. The action of bromine is less energetic than that of chlorine. To get the iodide it must be slightly heated."

GLUCINIUM.

By L. F. NILSON AND O. PETTERSSON.

GLUCINIUM in its salts presents certain analogies both with the magnesium and with the aluminium group, but no decisive clew is afforded to the true atomicity of the metal, which can only be deduced from its specific heat. The preparation of the metal is difficult; the authors could not succeed in obtaining it from its chloride by the electric method, and they adopted, therefore, the process of Wöhler and Debray, decomposing the chloride with potassium or sodium in a wrought-iron crucible closed with a screw. Glucinium thus obtained is a steel or tin-gray metal, of the sp. gr. 1·901 at 0°. It is hard and crystallizes readily. If melted it breaks under the hammer, and does not fuse at a temperature where salt is readily volatilized. It is inalterable in the air, and even at a red heat in a current of oxygen. Vapor of sulphur does not affect it. Before the oxidizing flame it becomes covered with a layer of oxide, but does not take fire. It has no action upon water either warm or cold. It decomposes hydrochloric and hydrosulphuric acid and the alkaline hydrates, hydrogen being evolved very briskly if heat is applied. Nitric acid attacks it more slowly. The sp. gr. of the impure metal being 1·9101, that of pure glucinium from its known composition was calculated at 1·64. The specific heat of glucina between 0° and 100° is 0·2471. Hence it must be considered analogous to aluminium, its atomic weight being 13·8, and its oxide having the formula Be_2O_3.

JAPANESE ISINGLASS.

By HARRY NAPIER DRAPER.

THIS product was given to me some time since by Dr. Aquilla Smith, who had procured it in the London Docks. It is in the form of flattened, somewhat contorted, and always curved threads, the longest of which does not exceed six centimeters, and they may perhaps be as accurately as possible described by saying that they resemble in form Nelson's Opaque Gelatine, but are very much more opaque and have much less color. That the substance is not isinglass may be at once decided by burning one of the threads, when it will be found that no odor of charred animal matter is evolved. Shortly summed up, the properties of this body are as follows:—It is turned blue by iodine, and is insoluble in alcohol, water even after many hours' boiling, dilute potash solution, acids, ammonia, and ammoniacal copper sulphate. My friend, Dr. Richardson has been kind enough to make for me two sections of this substance. These examined by the microscope show a ruptured cellular structure, but no indications whatever of starch granules. I bring forward this note in order that those whose attention may be called to it, and who may have met with this or other allied substances, may be induced to communicate any information of which they may be possessed. I should myself have pronounced it to be the Gelose of Payen, a body extracted from Gelidium Cornelum and other Algæ, were it not that this substance is described as being soluble in boiling water, and as yielding a translucent jelly, while the so-called "Japanese Isinglass" is quite insoluble. Nor in the descriptions of Payen's Gelose which I have seen is it mentioned that it is colored by iodine. At the time, now nearly a year since, when Dr. Smith gave me this specimen, I made several inquiries in London as to its existence, sources and uses, but without the slightest success.

Although not true isinglass, it seemed possible that the article under examination might be some other product of the animal kingdom. This would involve the question whether or not it contained nitrogen.

This point may be decided by a qualitative test, which, being applicable to all such cases, I may be excused for naming, though it is to be found in several modern textbooks of analysis. This test is best applied as follows:—You cut from a clean lump of sodium a few parings with a knife, and intimately mix them on the bottom of a small porcelain crucible, with the suspected substance in as minute a state of division as possible. Then the mixture is ignited. When it has become cool it is heated with water, filtered, and a mixed solution of a per and proto-salt of iron added, and afterward hydrochloric acid. Russian isinglass thus treated gives a copious precipitate of Prussian blue.

Since this paper was read Mr. Grindley has pointed out that this so-called Japanese isinglass dissolves readily in glycerine, and gives a clear and firm jelly. This jelly is colored blue by iodine.

GALLIUM.

By M. BERTHELOT.

M. LECOQ DE BOISBAUDRAN having placed at the author's disposal an ingot of gallium weighing 34 grms., he determined its specific heat, both in the solid and the liquid state, and also its melting heat, making use of his ordinary methods with the water calorimeter. Gallium melts at + 30°, but it may be kept liquid in a state of superfusion down to near 0°. The specific heat in the liquid state was determined twice, one experiment between 119° and 13°, and the other between 106° and 12·5°; the value found was 0·0802. The solid specific heat between 23° and 12° was found = 0·079. This determination must not be made too near the point of fusion. The melting heat is determined by introducing some crystals into superfused gallium, when the metal crystallizes rapidly. At 13° the author obtained the mean result + 19·11 cals. This number remains sensibly unchanged at all temperatures between 30° and 0°. If referred to the atomic weight, 69·9, it becomes 1·33 cals. The atomic specific heat in the liquid state = 5·59, and in the solid 5·52. This is the same as that of aluminium (5·53) and glucinium (5·64).

ACTION OF OXYGEN UPON THE ACID CHLORIDES, BROMIDES, AND IODIDES OF ALUMINIUM.

By M. BERTHELOT.

THE displacement of chlorine by oxygen with the formation of alumina should disengage a heat about +34·9. The displacement of gaseous iodine in the same manner liberates +109·5°, an enormous value, which explains the ignition of aluminium iodide. The same holds good with the iodides of phosphorus, silicium, arsenic, antimony, and tin, which are all combustible. The displacement of gaseous bromine by dry oxygen liberates +62·2.

A NEW WAY OF SEPARATING ARSENIC FROM OTHER METALS.

By MM. DE CLERMONT AND FROMMEL.

SUPPOSING a mixture of arsenic, antimony, and tin, the whole is converted into sulphides by treatment with sulphureted hydrogen, after having acidulated with hydrochloric acid, adding also tartaric acid if antimony is present. When the mixture is saturated it is allowed to stand in a warm place till the odor of sulphureted hydrogen is no longer perceptible, and is then thrown upon a filter and washed with much care, as the least residue of hydrochloric acid would cause a loss of arsenic in the state of chloride. The whole is then transferred into a flask full of water, and heated to a boil. The reaction is more rapid in a retort through which a current of air is passed. If the quantity of arsenic does not exceed 2 decigrms. the distillation of 500 to 600 c.c. of water suffices for the complete dissociation of the sulphides. The residue is then filtered, and the entire quantity of the arsenious acid is found in the filtrate, and determined by the ordinary methods.

DIBROMIDE OF ACETIC ACID.—C. HELL and O. MÜHLHÄUSER.—Although bromine and acetic acid do not react on one another in the slightest when brought together, the addition of a minute quantity of CS_2 causes at once a development of heat, and the mixture is changed rapidly into a mass of crystals of the compostion $C_2H_4O_2Br_2$. They form at first orange-colored tufts of needles, but change on standing into red thick prisms. The compound melts at 36°, is excessively hygroscopic, attacks the eyes, and can be sublimed. Water decomposes it. Other liquids, such as CCl_4 or $CHCl_3$, do not possess this peculiar catalytic action of CS_2, which only can cause the formation of this new molecular compound.

WOODBURYTYPE BLOCKS.

By Mr. W. B. Woodbury.

Where the subject is in line I make a positive photograph of it (*i. e.*, positive by transmitted light), and from this I obtain a relief in gelatine by the ordinary method, the result being that the hollows of the relief will all be of one uniform depth, this characteristic producing a level or uniform surface in the resulting mould, which I make by impressing this relief into metal by hydraulic or other pressure, or by the method stated in the second part of this invention. Where the subject is in half-tone, as in a photograph from nature, I proceed as follows:—In printing on the gelatine film I interpose between it and the negative a photograph on mica or transparent collodion of what is known as mosquito netting, or Brussels net, which breaks up the resulting relief into a multitude of fine square or hexagonal lines. To obtain from this a printing block I employ the means already described, the resulting block in soft metal being capable of giving from one hundred to two hundred impressions; but where large numbers are wanted I electrotype this block in the ordinary way. I use diffused light to produce the block from half-tone negatives, as in that case the light in the parts that represent the whites creeps around the lines, thus obliterating them in that part, and leaving them strongest only in the parts printing dark. I sometimes adopt another method. I take a negative of the network by transmitted light, and copy this together with the negative, thus producing a positive with the lines already thereon, from which I proceed to make a relief as stated.

To accomplish the second part of my invention I proceed as follows:—In place of using a thin film of collodion (as is generally used in the process called "Woodburytype") to hold the gelatine of the relief, I proceed as follows:—I first rub over a sheet of plate glass with French chalk or ox-gall, and then coat with the bichromatized gelatine solution as now used. When this is dried and ready for use I expose the side that was next to the glass for a few seconds to daylight before exposing it under the negative. This has the effect of causing a thin film of the gelatine to become insoluble, which after subsequent exposure under the negative will not wash away but form a support for the photographic image afterward impressed, thus doing away with the expense and trouble of the double coatings as now practiced. When the gelatine relief is dried in the ordinary way I take a thin sheet of tinfoil (same size as the gelatine relief) and attach it by gum or other adhesive substance round the edges to the gelatine relief. I now lay on the back of this a stout sheet of plate paper, and pass the whole through an ordinary rolling-press. The tinfoil is by this means impressed into all the details of the relief; but in that state it would be useless to print from. I then proceed as follows:—A shallow metal box is filled with a composition of shellac and asphalt, which on warming becomes soft, but hardens on cooling. This box is placed on a hot plate until the composition it contains softens; it is then placed on the lower plate of the ordinary Woodbury printing press, the foil and relief laid on it, the press closed, and the pressure applied by the under screw. When the composition has hardened the tinfoil adheres to it. I remove the gelatine relief from the foil, and use the foil-backed mould to print from. In place of fixing the proofs by alum or other substance of a like nature, I varnish the proofs with an ordinary varnish composed of shellac and alcohol, which gives the print the effect of a photograph on albumenized paper, at the same time protecting the surface from moisture. I also sometimes use the composition melted in boxes without the foil as a printing mould direct, and when sufficient numbers have been printed the box holding the composition is again heated, and can be used over and over again.

The third part of my invention consists in an improved method of printing "Woodburytype" by machinery. This I accomplish as follows:—Out of a solid block of iron I have turned a cylindrical hole, in which is made to fit very loosely a cylinder of soft metal having a taper or conical hole through it lengthwise. Between the interior of the steel block and the soft metal cylinder I insert the gelatine reliefs; then, by means of a taper or wedge-shaped spindle (roughened), I drive by hammering or by pressure the soft metal against the iron cylinder, thus impressing the relief on the outside of the metal cylinder, the taper spindle at the same time forming a shaft for the cylinder to be used in the process of printing. I then mount this roller bearing the relief in vertical slots in a frame having a bed of plate glass on which the paper rests, the roller resting on the glass by its own weight and being dragged round by the paper itself; or in place of the glass plate I allow the soft metal cylinder to lie on another fixed or movable roller of metal or glass. The latter may be hollow so as to reduce its temperature in hot weather by a stream of cold water running through it.

THE COLLODIO-CHLORIDE PROCESS.

By M. Geymet.

In this process the picture film can be removed and transferred to another surface; it can therefore be usefully employed in a variety of ways.

1. *The Collodion.*—Four solutions are required for preparing the emulsion:—

a.—Alcohol of 36°	100	c.c.
Silver nitrate	2	grms.
b.—Alcohol of 36°	100	c.c.
Strontium chloride	2	grms.
c.—Alcohol	100	c.c.
Citric acid	5	grms.
d.—Alcohol of 40°	100	c.c.
Ether of 62°	100	c.c.
Pyroxyline	4	grms.

The first three solutions are filtered. Into 100 c.c. of the raw collodion (*d*) pour first 10 c.c. of the strontium solution (*b*), and then 10 c.c. of the citric acid solution (*c*). This mixture is sensitized by dropping in 5 c.c. of the silver solution (*a*), which turns it milky. It is left in the dark till next day, and then the clear part, which alone is of use, is poured or drawn off from the sediment.

Alabaster paper is used for the support, and is prepared as follows:

Water	900	grms.
Baryta white	100	"
Gelatine	20	"

The gelatine is dissolved in the water bath, mixed with the baryta white, previously rubbed up in 100 grms. of water, and filtered through fine linen. A sheet of well sized paper is laid on a glass plate somewhat smaller than itself, and the edges are turned over and pasted on to the back of the plate. The white gelatine is spread evenly over the paper with a brush. When it is dry, the film is polished with a flannel rubber, and the edges are cut through.

This alabaster paper is laid on a smooth board, and the edges are turned up so as to form a kind of trough. The emulsion is poured evenly over the paper, and the board is placed in an inclined position. Only one film may be poured on the paper. The paper can be used directly after drying, but it will keep white and unaltered for a couple of months.

The following toning bath must only be used when the pellicle is to be transferred to another surface. Various other salts will give very fine tones, but they make the gelatine insoluble, and then it is impossible to separate the collodion from the paper. The print must be as intense as possible, as it weakens in the toning bath.

For the gold bath the formula is—

Water	1	liter.
Ammonium sulphocyanide	20	grms.
Double chloride of gold and sodium	1	grm.

Only so much of the bath must be taken as can be used on the same day. As soon as the picture is dipped into the bath it turns a straw-yellow, but after a while the color deepens. If this bath be poor in gold the picture will remain yellow for a long time, while too much gold gives it a disagreeable red tint.

The picture is fixed by immersion for four or five minutes in the following solution:

Water	1	liter.
Common salt	60	grms.
Hyposulphite of soda	100	"

The print is made clearer in this bath, and becomes finer than one on albumen, because the grain of the paper is concealed by the gelatine.

2. *Pictures on a Colored Ground.*—The baryta white in the gelatine can be replaced by other colors, as cobalt blue, blood-stone, cadmium yellow, etc. Charming moonlight effects are obtained with cobalt blue, and blood-stone is used for the reproduction of terra-cotta figures. As the blue-black tints do not come out well with these colors, a different toning bath, giving ruddier tones, must be employed, viz.:

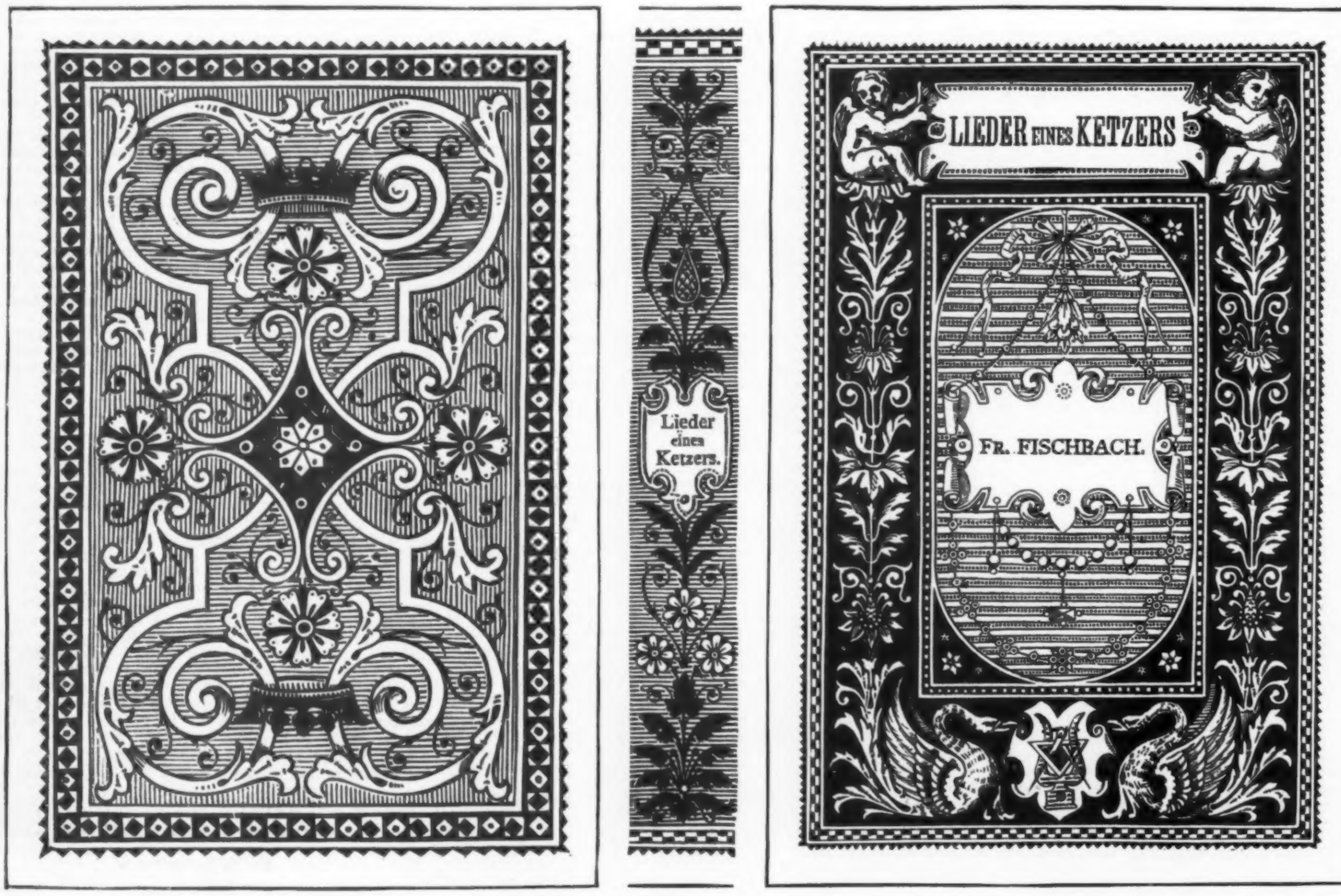
Water	1	liter.
Hyposulphite of soda	120	grms.
Common salt	60	"
Double chloride of gold and sodium	1	grm.

The pictures must not be washed too long; five to six minutes are sufficient, but the water must be often changed.

TRANSFERRING THE PRINTS.

3. *Pictures on Gold and Silver Paper.*—Reproductions of weapons and armor, and of medals and goldsmith's work, possessing the metallic luster of the original, can be obtained by transferring the pellicle to gold and silver paper. For this purpose pure gold and silver paper only may be used, as the imitation papers, which are made of copper and lead, soon oxidize, and the picture is ruined. To imitate old medals and coins, the gold or silver paper is coated with gelatine, in which, by means of a brush, green and yellow colors are unequally distributed. After drying, the pieces nearest in color to that of the metal or coin to be copied are cut out.

The collodio-chloride picture is transferred in the following way:—When toned and fixed, place it in a pan of warm water, the temperature of which must not exceed 80° C. In from two to three minutes the pellicle of collodion begins to separate from the paper; as soon as it detaches itself at the corners, it is time to transfer the picture. Lift the paper out of the bath without taking off the film, for the latter is much too delicate to be operated on alone; it must, therefore, be



SUGGESTIONS IN DECORATIVE ART.—BOOK COVER, DESIGNED BY PROF. FISCHBACH, HANAU. MADE BY G. FRITZSCHE, IN LEIPZIG.—*Workshop.*

left on the paper. The whole is laid, with the collodion film downward, on a glass plate, of which the dimensions are in each direction one centimeter less than those of the paper, and the protruding edges are turned over it. To remove the air-bubbles, press the paper on to the plate with the hand. Now turn the plate up again, and detach the paper, so that the pellicle of collodion remains attached to the glass.

It will be seen that the picture is, in this stage, not clear, because the film of baryta-white, which has rendered possible its separation from the paper, still remains attached to it. To remove this rub the film with a cotton pad dipped in warm water; the collodion is fairly tough, and able to withstand the rubbing better than might be thought. Not a particle of white must remain on the picture, nor yet on the reverse side. On this account, rinse the plate well on both sides under the water-tap. Next damp with water a sheet of ordinary white paper of the same size as the plate; lay it evenly on the collodion, and press out all air-bubbles with the hand. The edges of the collodion film, which were bent over the glass plate, are now turned over the paper, and the two together are drawn off the plate. Turn it up and place it on the same plate with the picture-side upward; rinse the film again under a jet of water. Rubbing with the cotton pad is not required, because the baryta-white has not settled on this side.

We now arrive at the transfer of the picture to its permanent support; this may be a piece of gold or silver paper, an ivory tablet, an enameled or porcelain plate, or a plate of opal or transparent glass, according as a transparent or a positive picture is required. Before the transfer, the support must be coated with a layer of gelatine when the support is hard, as in the case of glass, porcelain, or enamel; this coat must be allowed to get dry, but when the support is of paper this is not necessary.

Let us take the case of a hard support. Dissolve six to seven grains of gelatine in warm water, and filter it through paper; but wait till the solution is lukewarm, for only in this way can bubbles be avoided. Clean the plate thoroughly, and pour the solution over it, just as you would do with collodion; one coating will be sufficient. Place it in a position slightly inclined to the vertical on a piece of blotting-paper. In cold weather, warm the plate before coating it. When the gelatine has set remove the lump which will have set at the lower edge. Convex plates of enamel or glass must be dipped bodily into the gelatine, and then placed with their convexity upward on blotting-paper until the gelatine is perfectly dry. Immediately before the transfer the plate is dipped for a very short time in cold water, so as to soften the upper surface of the gelatine. The paper, with the picture-film downward, is then laid on the gelatine layer, pressed with the hand so as to remove superfluous water, and the plate placed on one side to dry, care being taken not to injure the picture by friction. Finally the white paper is taken off, and the picture is completed.

The picture is transferred to gold or silver paper as follows:—Lay the paper on a clean glass plate and moisten it slightly with a damp brush; turn it over and coat it on the metallic side with a very thin coat of gelatine by means of a brush. The picture film, after being well washed on both sides, must also be laid on a glass plate. Now place the gold or silver paper on the film, and press them together with a damp cotton cloth, so as to facilitate the paper spreading properly, and to avoid the formation of creases; the gelatine will attach itself to the collodion. Turn the picture, and leave it to dry on a clean glass plate; for the first five or six minutes of drying watch it carefully, and puncture with a fine needle the vesicles that keep constantly forming. Before finally fixing the film, retouch the picture with a mixture of Indian ink and carmine; then lay it on a small board, turn the edges of the paper over a cup or basin, and varnish with a mixture of equal parts of amber varnish and chloroform. Finally, polish the picture, and rub it in with cerate. By varnishing the picture loses its unpleasant metallic luster.

PICTURES ON ENAMELED PLATES.

These pictures look as well as those burnt in enamel, but are not so permanent as the latter. The plate is gelatinized according to the instructions given above, and the picture film placed to float on water. In order not to touch the plate with the fingers, it is laid on a curved strip of tin plate, and dipped into the water immediately below the film; the two are lifted out together. All folds or creases are removed by smoothing the film with a wet finger until it adheres completely. After drying and coloring, immerse the picture in a basin full of amber varnish, which dries immediately, giving great brilliancy to the picture, as well as rendering it firm and hard.

DIRECT PRINTS ON OPAL GLASS.

To obtain directly a film of collodio-chloride on glass, the following method must be pursued:—Clean the glass plate, coat it with white of egg, and let it dry. Then pour the collodion over it in the usual way, and when that has set, dip it into distilled water, and move it about on the dipper till the water runs over it evenly. Put the plate to stand in a nearly vertical position on filtering paper, and leave it to dry. It may be kept for a long time. Before using it must be fumed; to effect this, place a fuming box on its side, so that the plate may have a horizontal position. In the box place fifty grains of ammonium carbonate; insert the chloride of silver plate with its film downward, and close the box. The fuming will take a couple of minutes.

When using the common copying frame for pictures on opal glass, over-exposure will do no harm. There are special frames made for the purpose, in which the process can be watched, though they are by no means necessary.

Collodio-chloride must always be exposed in diffused light. After toning in the ammonium sulphocyanide bath, the picture can be reduced, even when it is much too dark (or burnt, as it is technically called), in a bath of two per cent. solution of potassium cyanide, without materially affecting the tone.—*Photographische Archiv.*

A NEW COLLODION.

M. ERNEST BOIVIN has introduced a new collodion to supersede that generally employed in the carbon process, in several dry processes, and in the albumen process where rapidity is required. He makes it by dissolving ordinary cotton wool in a solution of ammonia of 22°, containing fifteen per cent. of hydrated carbonate of copper. The cotton must be such as is usually taken for the manufacture of pyroxyline; it must be perfectly free from all fatty matter. M. Boivin first prepares the mixture of ammonia and copper salt, and, when their action is complete, he adds the cotton by small quantities at a time. It is then well stirred, and after the cotton has dissolved the solution is filtered through asbestos, or it may be left to settle in a bottle with a ground glass stopper, after which the liquid is decanted. If a collodion adhering easily to the glass plate be required to obtain opalescent films, a little resin must be added to the caustic solution. To coat the plate the mixture is poured on to it as with ordinary collodion; as soon as the film adheres, and is quite dry, it is immersed in water acidulated with nitric acid. This will at once cause the blue tint due to the copper salt to disappear, and when the plate has been washed there will remain only a film of pure cotton attached firmly to the glass. It may be again coated with albumen while still wet from the last washing, or it can be moistened only when it is desired to albumenize it. After the last washing also the bromo-iodide solution may be flowed over the film; then dry, or merely drain, and plunge into the silver bath with the ordinary manipulations for a silvered plate. Plates prepared in this way are highly sensitive. The solubility of cotton in an ammonia-copper solution having been long known, M. Boivin cannot understand why this property has not been before utilized in the same way as he has done.—ERNEST LACAN, *in Photographic News*

A PHYSIOLOGICAL HINT TO PHOTOGRAPHERS.

DISCOMFORT, amounting in many persons to actual distress, is experienced in sitting for a photographic portrait. The eye is fixed on a certain spot, and, while staring at this, vision becomes indistinct, surrounding objects especially being lost in a thickening mist. A feeling of giddiness, and even of faintness, is apt to follow if the sitting is at all prolonged. Dr. Thomas Buzzard says in the *Lancet* that while undergoing an ordeal of this kind a few days ago, the idea came across him that this strain was unnecessary, and could be avoided by a simple contrivance. Having begged a piece of paper and drawn upon it a circle of about four inches in diameter, he converted this into a sort of clock-face by adding the usual Roman figures in their accustomed places. The paper was then nailed to a post about eight feet distant, and when the sitting began he first fixed his eyes upon the figure XII., then upon I., II., III., and so on, "all round the clock," the gaze shifting leisurely from one figure to another. As anticipated, the sitting ended without any sense of strain, mist, or giddiness having been felt; and in place of the eager longing for release usually experienced, it seemed to him that he could have sat on without effort.

As Helmholtz clearly puts it, "to *look* at anything means to place the eye in such a position that the image of the object falls on the small region of perfectly clear vision. This we may call *direct* vision, applying the term *indirect* to that exercised with the lateral parts of the retina—indeed, with all except the yellow spot." The mistiness which occurs when the gaze is long fixed in one direction appears to come up from the periphery of the field of vision. This means probably that the fatigue of the nervous element is shown first in those portions of the retina which are least highly developed, and where vision is indirect. These parts in the ordinary method of procedure are subjected to a constant strain for a period which frequently amounts to sixty or seventy seconds. By the plan adopted, each movement of the eye which brought a new clock-figure upon the yellow spot necessarily shifted also the position of all surrounding objects in relation to the rest of the retina, fresh points of the nervous layer being thus presented to the action of luminous rays every three or four seconds. Hence fatigue of the nervous element never had time to occur. On the other hand, the rotatory movement of the eyeball in adapting itself, step by step, to the figures upon so small a circle at such a distance was so excessively fine as to cause no interference with the photographic process. Mr. Fradelle, who has since applied the suggestion in many other cases, writes to Dr. Buzzard that "the eyes are excellently well-defined, even to the iris; not alone yours, but all the pictures I have taken since have a marked superiority over those I had previously taken in the manner in which the details of the eyes are reproduced. In my opinion, the success of your idea is unqualified. I have questioned my sitters after the operation, and they express themselves as not having had any strain upon their eyes."

It is evident that the plan described is likely, incidentally, to prevent to a great extent the staring expression which the face assumes when the gaze is long fixed upon an object, for it combines a certain amount of free play of the eyes with accuracy of photographic definition. A somewhat larger circle, no doubt, may be employed with even greater advantage; and printed words, pictures, or other objects, may replace the figures. For children, and others who do not easily follow directions, a disk with a single aperture toward its edge might be made to revolve, in the direction of the hands of a clock, before another disk prepared with pictured objects of some kind or other, so that one would appear at a time at short intervals of space, and attract the eye. Various other modifications, indeed, at once suggest themselves as feasible, so long always as the figure toward which the gaze is directed presents a *succession* of objects arranged in a circular form.

IMPROVEMENTS IN ANILINE COLORS.

BRUNNER and Brandenburg report, in the *Berichte D. D. Chem. Ges.*, the results of their operations as to the use of bromine in the manufacture of aniline colors, especially aniline violet and diphenylamine blue. To three molecules of well-cooled and chemically-pure dimethylaniline they added three molecules of bromine in a thin stream, when a little hydrobromic acid gas escapes, but its development becomes much more abundant when the temperature rises to 248 degs. Fahr. The tough, dirty-green product is either mixed with a little acetic acid, and then kneaded into thin cakes, with quartz sand, and heated in the air-bath to 248 degs. Fahr., or it is at once heated in the oil-bath to the same temperature, being constantly stirred until a portion taken out congeals and separates on the addition of water, with a coppery luster. The purified coloring substance is a deep blue mass with a coppery reflection, readily deliquescent on exposure to air, soluble in alcohol, and dyeing silk and wool as intensely as BBBB (a very blue violet). If heated above 248 degs. Fahr. hydrobromic acid continues to escape, and redder dyes are formed; at 290 degs. Fahr., a reddish violet equal to BB; at 320 degs. Fahr., a shade resembling B. Between 338 degs. and 356 degs. Fahr. a product is obtained which dyes silk a fine red brown.

Three molecules of dimethylaniline, three of chloride of benzyl, and two of bromine heated to 248 degs. Fahr. for four hours yielded a sea-green product, soluble in water, along with a small quantity of a dye soluble in alcohol but insoluble in water. If one or two molecules of benzyl chloride are used to three of dimethylaniline, the authors obtained light or dark benzylated violets, which, like the blue green, are solid and of a coppery luster. For the synthesis of triphenylrosaniline (the basis of diphenylaniline blue), two molecules of diphenylamine and two of orthotoluidine were dissolved in glacial acetic acid, and six molecules of bromine were gradually added. The glacial acetic acid was then distilled off, and heat was applied for some hours, first to 302 degs. Fahr., and afterward to 356 degs. Fahr., until the mass became solid, and displayed a coppery luster. The purified color is scarcely soluble in water, readily in alcohol, with a splendid blue color, and dyes silk like BBB. The authors obtained sulphonic acid compound of the same as a dark-blue powder, perfectly soluble in water, and dyeing silk and wool blue.

Pure aniline, and aniline with toluidine (solid or liquid), and corresponding quantities of bromine yielded in every instance rosaniline along with traces of a violet-blue dye, insoluble in water.

RECENT IMPROVEMENTS IN ANILINE BLACKS.

By ANTONY GUYARD.

DYEING with aniline black is a question of enormous interest, and full of actuality. It was lately a difficult and delicate problem, but the reactions recently discovered have solved it in the happiest and most unexpected manner. The mixtures of vanadium contain no sensible amount of metallic salts, the traces of chloride of vanadium introduced having no sensible effect upon the doctors. As compared with the sulphide of copper mixtures, they offer the advantage of perfect homogeneity, and of a solubility which permits them to be applied upon all tissues. We may add that they offer all the advantages of the original mixtures of Lightfoot, without any of their inconveniences. They require, it is true, to be manipulated with care and precaution, but with the addition of the "preservative salt" of Castelhaz difficulties disappear, and the last objections and obstacles to the use of the aniline black are overcome.

To prepare the color for printing, we dissolve ⅞ ounce to 1¼ ounce of the chlorate of soda in 17 fluid ounces of water, and thicken in the ordinary manner.

At the same time 17 fluid ounces of water are thickened in another vessel, and 2¾ ounces muriate of aniline with 1½ grain of chloride of vanadium are stirred into it. The whole dissolves rapidly. Equal measures of the two pastes are mixed and printed on the muslins as rapidly as is wished.

As the black is readily developed, no more than the quantity strictly necessary must be mixed at once, and here, as well as in dyeing, it is necessary to age at a low temperature as long as chlorine is given off, and to raise the heat afterward until completely dry. The pieces are then passed through bichromate of potash, which completes the process. Nothing can equal the beauty of the blacks thus produced.

In dyeing, the choice of the chlorates is unimportant, and I admit that I have never obtained better blacks than with the chlorate of potash. Its only fault is imperfect solubility, and the dyer will therefore find a mixture of equal weights of the chlorates of potash and soda answer all his requirements.

In printing, the chlorate of potash is unsafe, because it is apt to crystallize on the surface of the colors, and produce accidents by blurring the patterns and smearing the grounds. Hence the chlorate of soda must be exclusively employed. In all cases, however, the "preservative salt" should be added to the aniline black, or rather to the mixtures from which it is prepared.

It is very important, to avoid excessive temperatures in the ageing-room, not to pile the pieces upon each other while still moist, and not to hang them up too near each other in chambers insufficiently ventilated.

The preservative salt of Castelhaz has the valuable property of absorbing or completely neutralizing the acids, the chlorine and the chlorated products given off during the development of the black. Hence the fiber is preserved from corrosion, other colors previously printed are not discharged or impoverished, and last, but not least, the health of the workmen is not exposed to injury.

This salt is perfectly soluble in water, and is no less useful in dyeing than in printing. If a slow development of the black is desired, ½ to 1 part of the preservative salt may be used to each part of chlorate of aniline, but if a more rapid development of the black is wished, or if other colors have been printed on before the black, the proportions may be raised to 1 to 1½. These proportions refer to dyeing as well as to printing.—*Teinturier Pratique.*

QUEBRACHO.

By J. ARNAUDON.

THE name Quebracho signifies break-hatchet, because of the extreme hardness of this wood, which, in appearance, is not unlike a bundle of fibers crossing each other like pins, after the manner of sanders wood. Leaving apart the chemical and physical characters of this dyewood, which may be found in the *Technologist*, I limit myself to saying that, in order to dye a yellow with this material, I used a solution of tin, dissolved in nitric acid and sal ammoniac, to which I added bitartrate of potash, for mordanting wool. The conditions necessary for dyeing and obtaining the best results are—(*a*) use a wood which has been as little exposed as possible to air and light—agents which have the effect of developing the red color in place of the yellow. (*b*) Avoid a temperature of 80 degs. Cent. (*c*) Avoid the presence of free acid in the bath. (*d*) Dye in presence of an excess of coloring matter placed in a bag. (*e*) The alumina mordants do not give rich fresh colors. (*f*) The bichloride, and especially the tin composition given above, are the best mordants for it. (*g*) Wool, in comparison with cotton and silk, is the material best adapted for dyeing with the Quebracho yellow.

KALLAB'S BLEACHING PROCESS.

THE essential part of this invention lies in the production of a permanent blue tint. The wool, previously scoured, etc., is taken through a beck in which 7½ to 15 grains of indigo are suspended per 22 gallons of water, next through a solution of hydrosulphite of soda; acetic acid is then added to the solution, and the wool is then taken through again. To every 35 fluid ounces of the solution of hydrosulphite, which should stand at 4 degs. Baumé, about 300 grains of acetic acid at 50 per cent. are added. After passing through this liquid the wool is exposed to the air, washed first in a weak soda-lye, and then in pure water, and finally dried at 95 degs. Fahr. The indigo, which was at first only deposited mechanically upon the fiber, is reduced by the hydrosulphite beck to white indigo, and then reprecipitated upon the fiber as indigo blue. The tint is, therefore, a vat blue and perfectly fast.—*Reimann's Farber Zeitung.*

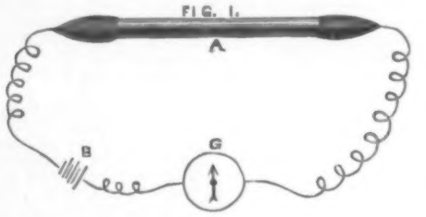
[ENGINEERING, London, May 30, 1878.]

THE HUGHES TELEPHONE.

THE eminent inventor of the well-known Hughes type-printer has recently made the startling discovery that certain unhomogeneous conducting substances placed in circuit with a battery possess the property of converting sonorous vibrations into undulatory currents of electricity, by which not only can notes and articulate speech be transmitted to a distant telephone placed in the circuit, but sounds so minute as to be otherwise inaudible can be magnified into loud noises. Of all the marvels connected with telephonic electricity we have no hesitation in saying that Professor Hughes' discovery of the sensitiveness of certain compound structures or unhomogeneous substances to minute vibrations is the most marvelous of all; it opens up a vast field of philosophical inquiry, and places in the hands of the physicist a detector of sounds and of other mechanical vibrations so small as to be altogether unsuspected. It in fact gives to him the means of constructing instruments which will be to the ear what lenses and microscopes are to the eye, and at the same time as a telephonic transmitter it is an improvement upon Professor Bell's telephone, transmitting louder and clearer articulation. But the most extraordinary part of Professor Hughes' discovery is the ridiculous simplicity of the apparatus employed; a few French nails, a few sticks of charcoal, a tube or two containing powders, a little sealing-wax, and a few pieces of wood, and any boy can in a few minutes construct a transmitting telephone surpassing in sensitiveness the beautiful instrument of Professor Bell, which it does not altogether supersede, for that instrument is still employed by Professor Hughes as the receiver.

We need hardly remind our readers that the sounds that are heard in a telephone are produced by the vibration of the metallic plate or diaphragm, which is set into motion by the variation of magnetic intensity in the permanent magnet placed behind it, which variation of magnetic intensity is produced by a current of electricity traversing the coils

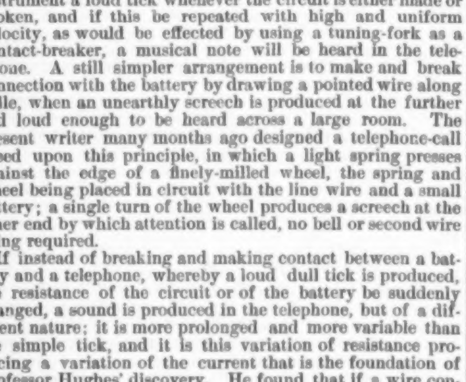
FIG. 1.



which is itself constantly varying in intensity according to the motion of the diaphragm at the distant station. It is not the current alone that produces these results, but the undulatory or constantly varying nature of that current. If at the distant station a single cell of a voltaic battery be substituted for the telephone, there will be heard in the receiving instrument a loud tick whenever the circuit is either made or broken, and if this be repeated with high and uniform velocity, as would be effected by using a tuning-fork as a contact-breaker, a musical note will be heard in the telephone. A still simpler arrangement is to make and break connection with the battery by drawing a pointed wire along a file, when an unearthly screech is produced at the further end loud enough to be heard across a large room. The present writer many months ago designed a telephone-call based upon this principle, in which a light spring presses against the edge of a finely-milled wheel, the spring and wheel being placed in circuit with the line wire and a small battery; a single turn of the wheel produces a screech at the other end by which attention is called, no bell or second wire being required.

If instead of breaking and making contact between a battery and a telephone, whereby a loud dull tick is produced, the resistance of the circuit or of the battery be suddenly changed, a sound is produced in the telephone, but of a different nature; it is more prolonged and more variable than the simple tick, and it is this variation of resistance producing a variation of the current that is the foundation of Professor Hughes' discovery. He found that if a wire conveying a current from a battery through a telephone be suddenly broken, a loud tick is produced in the telephone; but

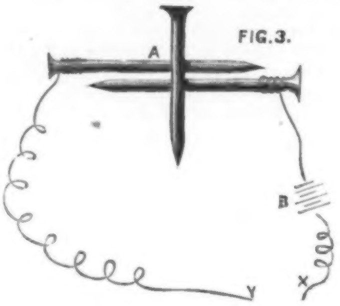
FIG. 2.



that if the wire instead of being suddenly snapped be subjected to a tensile strain so as to drag it asunder, there is heard a sort of preliminary murmur or grating sound before the actual snap takes place, and this phenomenon led him to go into the investigation which has led to such important results. We have no doubt that this grating noise is produced by the fibers which constitute the metallic wire beginning to give way and dragging over one another, producing a variation of resistance somewhat analogous to the dragging a wire over the surface of a file, which we have before alluded to.

Fig. 1 represents one of Professor Hughes' experiments, which is exceedingly interesting, and which illustrates in a most instructive manner what we believe to be the true explanation of the phenomena. A is a glass tube filled with a mixture of metallic tin and zinc, commonly known as "white silver powder;" this powder is slightly compressed by two plugs of gas carbon inserted at the ends, to which are attached wires having a battery, B, and galvanometer, G, in circuit. The plugs are cemented in their place by being covered over with ordinary sealing-wax. Upon grasping this tube by the two ends, and giving it a tensile strain by pulling the two ends in contrary directions, but in a line with its length, the galvanometer needle is deflected in one direction, and on pushing the ends toward one another, so as to put on a strain of compression, the needle of the galvanometer is instantly deflected in the opposite direction. In this case the finely-divided metallic particles forming the contents of the tube are brought into more intimate connection by compression, and are more separated during the operation of extension, and thus the resistance of the circuit is varied, increasing the current in the first instance, and decreasing it in the second. If this view be correct the movement of the galvanometer needle in the reverse direction cannot be called a deflection, but a returning to zero, stopping at that position which represents the strength of the current flowing through its coils when the tube is being extended. This experiment alone would be a remarkable example of the marvelous sensitiveness of the telephone as a detector of minute variations of electrical force, for it is hardly possible to conceive the minute increment that takes place in the

FIG. 3.

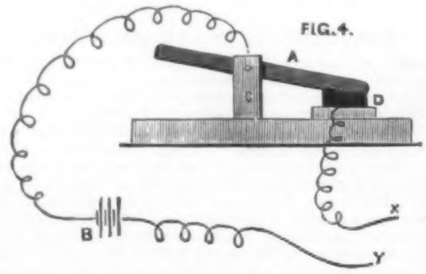


length or capacity of a glass tube, some 3 ins. long, when extended by pulling with the fingers. But this sensitive tube is far more delicate than is shown by the last-named experiment. So sensitive is it that it is capable of taking up sonorous vibrations, and by its own vibrations under their influence it transmits through an electric wire to a distant telephone undulatory currents capable of reproducing therein all the sounds by which they were produced, and with even greater perfection than would be attained if a telephone were the transmitting instrument. By attaching one of these tubes to a small resonating box as shown in Fig. 2, Professor Hughes has made what we have no hesitation in saying is the very simplest electric articulating telephone that has ever been produced. It consists of nothing more than a tube of glass filled with a powder whose electric conductivity can be varied by variations of compression, wires being led from the two ends, and this little apparatus attached to a little box opened at one end, which serves as the mouthpiece of the instrument; the wires are attached to a distant telephone of Professor Bell's construction, and have a battery of three small Daniell cells in circuit. In the original instrument made by Professor Hughes the resonator consisted of a child's halfpenny money box, one end being removed, and the tube attached to the top by ordinary sealing-wax. Indeed the whole of the apparatus employed by Professor Hughes is of the rudest possible description, and is an eloquent example of the fact so loudly proclaimed by many of the instruments in the late Loan Collection of Scientific Apparatus, that with the simplest and roughest apparatus many of the greatest discoveries of science have been made. With this simple telephone the sounds are so loud that it is possible to sing into one instrument and hear at the same time singing from a distant station in another. This duplex arrangement with a single circuit works perfectly, the one communication in no way interfering with the other.

When a stick of pure vegetable carbon, such as is used by artists, is employed instead of the tube, no effect is produced, because of its very high resistance making it to all intents and purposes a perfect non-conductor, but by heating it to incandescence and suddenly plunging it into a bath of mercury, it becomes impregnated with minute particles of that metal, and in that state can be used almost as well as the tube of compound metallic powder. Similarly charcoal impregnated with platinum-perchloride may be used with advantage, whether in the form of a stick or as powder contained in a tube.

Professor Hughes has been experimenting with various substances, but the results seem to show that whatever conductor is employed, it must not be homogeneous in its nature, so that increase or decrease of pressure by producing closer or more distant union between its conducting particles has the property of varying the strength of the current transmitted, giving to it an undulatory character. A tube containing clean lead shot will exhibit the phenomena, but after a time, in consequence of an insulating oxide being formed on the surface of each shot, it ceases to convey the current. Possibly by immersing the shot in a non-oxidizing medium, such as naphtha, the defect might be remedied,

FIG. 4.

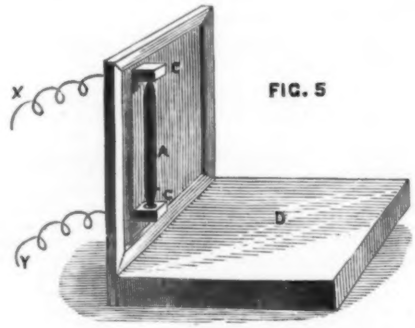


but far better substances for the experiments can be found than shot.

Ordinary mechanical structures which contain a good many joints, such as a small machine or a small chain made into a little heap, act almost as well as the substances to which we have referred. In these special cases the phenomena are probably due to the electric current having imparted to it an undulatory character through being transmitted through a circuit containing a number of what the telegraph engineer would call "faults," which are variable in their faultiness, through variations of pressure between the separate parts of the conducting structure. The simplest form of such a structure is shown in Fig. 3, in which two common French nails, A, are fastened down to a horizontal board about a millimeter apart; wires, X and Y, are attached to them leading to a battery, B, and a telephone in such a manner that the nails form the only break in the circuit, which can be closed by laying any conducting material across them. When a third French nail is laid across the other two it is clear that (as a cylinder can only touch another cylinder whose axis is not parallel with it in a single point) the electric circuit has a very imperfect connection at the points of contact between the nails, and it is to this faulty connection that the sensitiveness of this arrangement is due. Incredible as it may appear to those who have not seen this experiment, it is nevertheless a fact that this simple contrivance is a very perfect articulating telephone, and words spoken or songs sung to the little French nail, which we may suppose dances on the other two to the articulation and to the tune communicated to it, are instantly transmitted to the receiving instrument at the further end of the line with marvelous distinctness and power. An improved effect is produced by the substitution of sticks of gas-carbon for the nails, Professor Hughes having made the discovery, important to makers of telegraphic relays and of electric clocks, that for very light contacts carbon makes better electric connection than any metallic conductors.

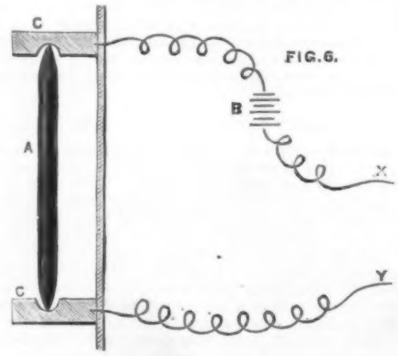
In order to test the influence of pressure upon substances experimented on, Professor Hughes has employed a little clip shown in Fig. 4, in which A is a small bar of brass hinged to a support, C, which is fixed to a little board; the substance to be tested is placed between the jaws at D, and pressure can be increased or diminished by placing small weights on the bar A on one side or other of its pivoted center. The bar is attached through C to the battery B, and the lower jaw is connected with the telephone and battery by the wires X and Y. In all these experiments Prof. Hughes uses a small drum clock as the source of sound, the test being the loudness of tick heard in the distant telephone, when the clock is placed at different distances from the

FIG. 5



transmitter. With this instrument powders and various substances have been tested under different pressures, as well as compound structures such as small portions of a chain heaped between the jaws, which, under a certain pressure, make a very efficient articulating telephone, and a block composed of powdered black oxide of iron made up with gum transmits the ticking of a clock with great perfection.

We now come to what is by far the most sensitive apparatus constructed up to the present time by Professor Hughes in the course of this research, and here again the apparatus is remarkable for its extreme simplicity. Fig. 5 represents what is without doubt the most sensitive acoustical instrument next to the human ear itself that has ever been constructed. It consists simply of a small pencil of gas carbon, A (such as is used in the electric lamp), pointed at each end, and lightly supported in a vertical position (see detail sketch, Fig. 6) between two little cups, scooped out of the surface of small carbon blocks, C C, which are attached to a thin sounding-board secured to a more solid base board, D. The blocks C C are connected by the wires X and Y to the battery and line-wire leading to the telephone. This marvelous apparatus, rough as it is (and it is impossible in a drawing to convey the extreme roughness of the original instrument constructed by Professor Hughes), is the most delicate instrument we have ever seen in the whole realm of physics. Not only is articulate speech taken up by it and transmitted



by it to a distant station with great power and distinctness, but it detects and converts into loud noises the minutest possible vibrations. The slightest stroke or the lightest touch given to the base board is sufficient to produce a loud grating noise in the telephone; even the tip of a soft camel's hair pencil gently stroked along the table on which the instrument is placed is faithfully recorded as a rustling sound, and, what is still more extraordinary—and we will pardon our readers if they suspend their belief in the statement until they verify it for themselves—the very footfalls of a little common housefly as it walks along the board D are heard with unmistakable distinctness by a person whose ear is at the distant telephone, which may be miles away.

While these interesting experiments show the marvelous sensitiveness of Professor Hughes' apparatus for the conversion of sound waves into waves of electricity, they also prove, more than anything that has hitherto been done, the extraordinary delicacy of the telephone of Professor Graham Bell as an instrument for receiving those electrical impulses and reconverting them into sonorous undulations. And both parts of the apparatus, the transmitter of Professor Hughes and the receiver of Professor Bell, bring before the mind the still higher perfection and sensitiveness of the human ear, whose powers as an acoustical instrument we are only now beginning to appreciate.

A PROJECTION PHONEIDOSCOPE.

By GEO. H. STONE, Kent's Hill, Me.

BY combining the essential features of the phoneidoscope (described in the SCIENTIFIC AMERICAN SUPPLEMENT No. 122) with President Morton's method of projecting interference tints, the sound vibration figures of soap films can easily be projected and even measured on the screen before an audience. The method has also this advantage, that the movements in the whole film can be observed at once. A bright light is needed, preferably from the sun or electric lamp. A beam of light falls obliquely on the film and the reflected beam is passed through a convex lens. A better effect is secured by holding the film vertically; when it is horizontal, reflection from mirrors is needed, which causes a great loss of light. Films from one and a half to two inches in diameter are so strong that they become monochromatic before bursting, and last longer when in vibration than when still. Under the action of sound pulsations the film becomes violently agitated, rapid vortical motions ensue, polygonal figures bounded by bright lines appear, and often in the center of each is a whirling spot of light, connected with the perimeter of the polygon by faint vortical or nodal lines. A circular film breaks up into variously shaped polygons, while a square film has a decided tendency to break into nearly regular squares, and a hexagonal film into hexagons. The interference colors are very brilliant, and the whole forms an instructive and beautiful experiment, the figures varying with every change in the pitch or quality of the voice or sounding body.

THE COMING TOTAL SOLAR ECLIPSE.

By J. NORMAN LOCKYER.

THERE is no doubt whatever that the eclipse which will sweep over the United States next July will be observed as no eclipse has ever been observed before. The wealth of men, the wealth of instruments, and the wealth of skill in all matters astronomical already accumulated there, make us Old Country people almost gasp when we try to picture to ourselves what the golden age will be like there, when already they are so far ahead of us in so many particulars.

Draper, Hall, Harkness, Holden, Langley, Newcomb, Peters, Peirce, Pickering, Rutherfurd, Trouvelot, and last, but not least, Young, are the names that at once run easily off the pen to form a skeleton list, capable of considerable expansion with a little thought, when one thinks of the men who will be there. One knows, too, that all the enthusiasm of devoted students and all the appliances of modern science —appliances in the creation of which many of those named have borne so noble a part—will not be lacking. So that we may be sure that not only all old methods but all possible new ones will be tried to make this year one destined to be memorable in the annals of science side by side with 1706, 1851, 1860, and other later years.

Thank heaven, too, there is no necessity that the thankless task of organizing an "Eclipse Expedition" from this country should fall on any unfortunate individual, among other reasons because—and this is a very hopeful sign of increasing general interest taken in scientific work—Messrs. Ismay, Imray & Co., the owners of the White Star Line, have expressed in the warmest manner their desire to aid English observers by a considerable reduction of fares, and the directors of the Pennsylvania Railway Company, as the readers of *Nature* have already been made aware, have done the like in the case of observers coming from Europe in their individual capacity.*

The progress in that branch of knowledge which requires the aid of eclipse observations has been so rapid during the last few years, that the eclipse of 1868, though it happened only ten years ago, seems to be as far removed from the present as the Middle Ages are in regard to many other branches of culture. The work done by the spectroscope since that year, when in the hands of Janssen, Pogson, Herschel, and others it added so enormously to our knowledge, has gradually covered larger and larger ground, and each successive eclipse in 1869, 1870, 1871, and 1875 has seen some variations in its use, so that its employment has proved the most novel, if not the most powerful, side of the attack.

Young's work of 1869 will no doubt form the keynote of much that will be done this year so far as the coronal atmosphere is concerned. It will be remembered that Young in 1869 observed a continuous spectrum, while Janssen in 1871 observed a non-continuous one, for he recorded the presence of the more prominent Fraünhofer lines, notably D. This positive observation from so distinguished an observer demands attention, not only on its own account, but because of the question which hangs upon it, which is this: Does the corona reflect solar light to us or does it not, and, if it does, *where* are those particles which thus act as reflectors? On this point the photographs taken in Siam in 1875 are silent, as the method employed was not intended to discriminate between a continuous and a discontinuous spectrum.

But, although this point remains, how greatly has the ground been cleared since 1869. That wonderful line, "1474," is more familiar to us now; and yet there has been almost a chapter of accidents about it. In the first place, with regard to this line above all others, there appears to be a mistake in Angström's map; the solar line at 1474 is not due to iron at all; with the most powerful arc there is no iron line to be seen there. Then Secchi attributed it to hydrogen, though I am not aware on what evidence. But, whatever be its origin, the fact remains that we now know by its means that the solar hydrogen is traversed and enwrapped by the substance which gives rise to the line to an enormous height, so that it forms the highest portion of the atmosphere which is hot enough to render its presence manifest to us by spectral lines. Here, so far as I know, only one point of difference remains. In 1871 I most distinctly saw the line trumpet-shaped, that is, with the base broadening as the spectrum of the photosphere was reached, while Janssen saw it stopping short of the spectrum of the photosphere. The importance of this point is that, supposing one of us to be mistaken, and one or other observation to represent a *constant* condition, then, if the line broadens downward till the sun is reached, we are dealing with a gas lighter than hydrogen, capable of existing at a high temperature, which thins out as the other gases and vapors do, in consequence of its vapor density being below that of hydrogen; or, on the other hand, if the line stops short as a constant condition, it represents a substance which is probably dissociated at the lower levels, and is therefore probably a compound gas; and then the question arises whether it has not hydrogen as one of its constituents.

Perhaps I may conveniently refer to a paper of mine which was lately read at the Royal Society in this connection, because it may be that the solar regions most worthy of the closest study at the present time are precisely these higher reaches of the sun's atmosphere. There is little doubt, I think, that around the sun's visible atmosphere matter exists at a temperature low enough not to give us its autobiography in the bright line manner, and there is evidence that matter existing under such conditions, absorbing as it must do some of the sun's light, will, if it remains elemental, give us an absorption of the fluted kind, or again will absorb only in the blue or ultra-violet region.

Now the more the chemistry of the reversing lower layer of the sun's atmosphere—that in which the upper level of the photosphere is bathed—is examined, the more metallic is it found to be. For instance, my own work has enabled me to trace with more or less certainty eighteen metallic elements,* in addition to those recorded by previous observers; but of metalloids in this region I have traced none. The persistency with which metal after metal revealed itself to the exclusion of the metalloids led me to throw out the idea some time ago that perhaps the metalloids lay as a whole above the metals, and shortly afterward I obtained evidence which seemed to me of a very satisfactory nature as to the existence of carbon, its presence in the sun's atmosphere being rendered probable by fluted bands, and not by lines. There were two points, however, which remained to be settled before the matter could be considered to be placed beyond all doubt.

The first was to establish that the fluted bands generally present in the spectrum of the electric arc, as photographed, which bands vary very considerably in strength according to the volatility of the metal under experiment, were really bands of carbon—a point denied by Angström and Thalén.

This point I have settled by two photographs, in which the carbon bands remain the same, though one spectrum is that of carbon in air, the other of carbon in dry chlorine.

The next point was to insure accuracy by the most positive evidence that there was absolutely no shift in the carbon bands. Such a shift is produced when the part of the arc photographed is not perfectly in the prolongation of the axis of the collimator of the spectroscope. Its effect is to throw the lines of iron, for instance, a little to the right or a little to the left of the Fraünhofer lines with which they really correspond.

I have now obtained a photograph which supplies such evidence. There are metallic lines close to the carbon bands which are prolongations of Fraünhofer's lines, while the lines which I have already mapped at W. L., 39·27 and 39·295, in the spectrum of iron, are also absolute prolongations. Therefore there is no shift in the carbon flutings, and the individual members of the fluted spectra in the brightest portion are absolute prolongations of a fine series of Fraünhofer lines in the ultra-violet.

Now how does this connect itself with observations of the upper parts of the solar atmosphere?

Angström has already shown that the true carbon *lines* which we get when a coil and jar are employed are not reversed in the spectrum of the sun, and I have already shown that the calcium spectrum in the sun is similar to the spectrum obtained when the spark, and not the arc, is employed. Accompanying the change from a high to a higher temperature there is a change in the intensity of the lines—some thicken, others become thinner. We can only match the relative thickness of the solar calcium lines by employing a very powerful coil and jar—so powerful, indeed, that the lines, and not the flutings, of carbon would be visible in the spark given by it. It is fair, then, to say that, if carbon were present with the calcium *in the sun's reversing layer*, we should get the lines of carbon when we get the calcium lines appearing as they do.

As we do not get this evidence, we are driven to the conclusion that the carbon vapor exists not only in a more complicated molecular condition (as is evinced by the flutings) than the metallic vapors in the sun's atmosphere, but at a lower temperature. It must, therefore, exist *above the chromosphere*, that is, in a region of lower temperature. Lower pressure, again, is indicated by the feeble reversal, so that everything points to a high level.

The question is, will this region be recognized during the coming eclipse?

Coming down lower we reach a level better known, and of which, perhaps, the interest during the eclipse will now be less, if we except the possibilities opened out to us by photography. One good photograph of the lines visible in the lower cromosphere will be of incalculable value. Attempts may be made on the cusps just before and after totality, and if only one of these succeeds we shall have the ordinary solar spectrum as a scale. If good pictures near H can be secured, enough information now exists for that region to enable us to determine the chemical origin of the bright lines photographed. These remarks apply to attempts made with spectroscopes furnished with slits in the ordinary way; there is little doubt, however, that the method utilized for the Siam eclipse in 1875, the method suggested by Prof. Young and myself for the Indian eclipse of 1871, will also be taken advantage of; here the cromosphere itself becomes the slit. A dispersed series of spectral images of the thing itself, instead of the spectrum of a part of the image of it focused on a slit, is obtained, the position of each image in the spectrum enabling its chemical origin to be ascertained if only a comparison spectrum can be secured at the same time.

In 1875, in the expedition to Siam, the photographs of this nature were obtained by means of a prism, and the results obtained by that expedition led me to think that, possibly, this method of using the coronal atmosphere as a circular slit might be applied under very favorable conditions if the prism, or train of prisms, hitherto employed, were replaced by a reflection grating, with which the generosity of Mr. Rutherfurd has made many of us familiar for the simple reason that, while a prism only gives us one spectrum, a brilliant grating placed at right angles to an incident beam gives us spectra of different orders, so-called, on each side of the line, perpendicular to its surface. Of these two or three are bright enough to be utilized on each side, so that we can get six in all.

To test this notion I made the following experiment with a grating given to me by Mr. Rutherfurd. This magnificent instrument contains 17,280 lines to the inch, ruled on glass, and silvered. Its brilliancy is remarkable:

In front of the condenser of an electric lamp adjusted to throw a parallel beam I placed a circular aperture, cut in cardboard, forming a ring some 2 inches in interior diameter, the breadth of the ring being about ⅛ inch. This was intended to represent the chromosphere, and formed my artificial eclipse.

At some distance from the lamp I mounted a 3¾ inch Cooke telescope. Some distance short of the focus I placed the grating; the spectrum of the circular slit, illuminated by sodium vapor and carbon vapor, was photographed for the first, second, and third orders on one side. The third order spectrum, showing the exquisite rings due to the carbon vapor flutings, was produced in forty-two seconds. The first order spectrum, obtained in the same period of time, was very much over-exposed. It is, therefore, I think, not expecting too much that we should be able to take a photograph of the eclipse, in the third order, in two minutes. Similarly we may hope for a photograph of the second order in two minutes, and it is, I think, highly probable also that a photograph of the first order may be obtained in one minute. To make assurance doubly sure, the whole of the totality may be used during the coming eclipse, but if there be several such attempts made, it will certainly be worth while to try what a shorter exposure will do.

Now by mounting photographic plates on both sides of the axis, one solidly mounted equatorial of short focal length may enable us to obtain several such photographs, with varying lengths of exposure. I insist upon the solidity of the mounting, because, if any one plate is to be exposed during the whole of totality, the instrument must not be violently disturbed or shaken while the eclipse is going on. I think, however, it is quite possible to obtain more than one photograph of the lower order spectra without any such disturbance in this way. The same plate may be made to record three or even four exposures in the case of the first order in an eclipse of four minutes' duration, by merely raising or lowering it after a given time, by means of a rapid screw or other equivalent contrivance, so that a fresh portion of the same plate may be exposed. Similarly the plates on which the spectra of the second order are to be recorded may be made to perform double duty.

If one equatorial thus mounted were to be devoted to each quadrant of the coronal atmosphere, it is certain, I think, that most important results would be obtained.—*Nature.*

* In fact Messrs. Ismay, Imray & Co. have just announced that they will take properly certified observers and bring them home again for the sum of £30 which is rather less than 1st class single fare; so that English observers will be carried to Denver or the Rocky Mountains and back again for the sum of £34.

* These are strontium, lead, cadmium, potassium, cerium, uranium, vanadium, palladium, molybdenum, indium, lithium, rubidium, cœsium, bismuth, tin, lanthanum, glucinum, and yttrium or erbium.

ON THE AEROLITIC EPOCH OF NOVEMBER 12TH–13TH.*

By PROF. DANIEL KIRKWOOD.

IT is now well known that clusters of small meteors—the so-called shooting stars—move in elliptic orbits about the sun. Catalogues of fire-balls and meteoric stones indicate, moreover, that groups of *larger bodies*, somewhat widely dispersed, revolve in like manner about the center of our system, their orbits in certain cases intersecting that of the earth. The 12th and 13th of November is one of these *aerolitic epochs*, the date being nearly coincident with that of the great November shower of falling stars. The writer until recently supposed the meteorites of this epoch to revolve in the same orbit with the nebulous swarm which furnished the showers of 1833, 1866 and 1867.† Later study of the facts, however, has rendered the theory of this intimate relation extremely improbable. The principal phenomena of this epoch (not including star showers) are the following:

(*a.*) 1582, meteoric phenomena at Zurich.
(*b.*) 1765, an extraordinary meteor at Frankfort.
(*c.*) 1820, a detonating meteor seen in Russia.
(*d.*) 1822, fall of aerolites at Potsdam and Leipzig.
(*e.*) 1828, a great meteor seen in full sunshine in France.
(*f.*) 1835, a fall of aerolites in France.
(*g.*) 1849, a fall of aerolites at Tripoli.
(*h.*) 1849, a large meteor seen in Mecklenberg.
(*i.*) 1856, a metoric stone fell in Italy.
(*j.*) 1877, a brilliant meteor seen in Arkansas and another in Wisconsin.

REMARKS.

(*a.*) This so-called "fall of fire from heaven" occurred on the 28th of October, O. S., or November 7th, N. S. Making allowance for the precession of the equinoxes, the date corresponds at present to the morning of November 12th.

(*b.*) This bolide was observed November 11th, and is the only one in our list which occurred *very* near the epoch of the great star shower in November.

(*c.*) See Greg's catalogue of fire-balls and meteoric stones; also Quetelet's catalogue of shooting stars.

(*d.*) Several aerolites fell at this date near Potsdam, and also at Taucha, near Leipzig, about 75 miles distant.

(*e.*) See Quetelet's catalogue.

(*f.*) This fall of aerolites occurred on the evening of November 13th, in the department de l'Ain, France. The meteor was *unconformable* to the radiant of the Leonids, its motion being from southwest to northeast. A fragment is in the collection of Prof. Shepard, of Amherst, Massachusetts.

(*g.*) The meteoric phenomena of this date are thus described in the catalogue of Mr. Greg: "Seen in the southern sky. Varied in color; a bright cloud visible one and a half hours after; according to some a detonation heard fifteen minutes after bursting. Seen also like a stream of fire between Tunis and Tripoli, where a shower of stones fell—some of them in the town of Tripoli itself."

(*h.*) This fire-ball appeared on the same evening or night. —Greg's catalogue.

(*i.*) This aerolite fell at Trezano. A fragment is in the collection of Prof. Shepard.

(*j.*) A large meteor was seen by Professor Robert C. Hindley, of Racine, Wisconsin, on Sunday evening, November 11th, at three minutes past six o'clock (Chicago time). This meteor is thus described by Professor H. in the SCIENTIFIC AMERICAN for December 1, 1877: "Direction N. E.; altitude at commencement of course about 30°; length of course from 10° to 12°; time of falling about 8 seconds. It fell toward the west, making an angle in falling to the earth of about 65° with the vertical passing through the body. During the latter three-fourths of its course, its length, including the luminous trail, was about one-half of a degree. The nucleus was very brilliant; its color at first a yellowish-white, then a light green, and lastly, a greenish-yellow. Could its color have been due to boron, thallium, etc.? I find no record in any of the numerous analyses of meteoric stones of the presence of elements likely to give the green color."

On the following evening, November 12th, at 6h. 26m. (Memphis time), Frank L. James, Ph.D., M.D., of Osceola,

* Read before the American Philosophical Society, March 1, 1878.

† A list of stone-falls, detonating meteors and large fire-balls which have appeared about this epoch is given in Meteoric Astronomy, pp. 58–60.

Arkansas, saw another meteor in the same part of the heavens, and in some respects so strikingly resembling that observed in Wisconsin, that he was disposed, on reading Prof. Hindley's description, to think they had observed the same phenomenon, and that one or the other had mistaken the date. I have, however, corresponded with both the gentlemen, and have found that the meteors were seen on different evenings. "The date is fixed," says Dr. James, "not only by my own 'case-record' but by that of a friend and brother physician who assisted me in an amputation on the previous day." The following account of the Arkansas meteor is extracted from Dr. J.'s communication in the SCIENTIFIC AMERICAN for December 29th, 1877: "I was startled by a sudden glare of light which seemed to come from right in front of me. Throwing up my eyes I saw a large and very brilliant meteor in the northeast, falling apparently nearly straight downward, with a slight deviation to the east. When I first saw the meteor it was about 30° in height, and judging from the length of time it took to travel the remainder of its course, it must already have fallen 3° or 4°. It fell through an arc of about 12° or 15° in all, and was about ten seconds in falling. When I first saw it it had a golden hue which suddenly changed to green, or that peculiar shade produced by burning chlorate of potash with nitrate of barium and sulphur. The light shed by it was pulsating and sufficiently powerful to light up the Tennessee shore and the sand bars, so as to show every log and stump."

PROBABLE INFERENCES.

1. The number of stone-falls and detonating meteors observed on the 11th, 12th and 13th of November is more than double the average daily fall. Hence the periodic return of a cluster whose orbit intersects that of the earth is rendered highly probable.

2. None of the aerolites or meteors of the preceding list are known to have been conformable to the radiant in Leo, while those of November 13th, 1835, and November 12th, 1877, were certainly unconformable, their heliocentric motion having been direct. The aerolitic group cannot therefore be connected with the shooting stars of November 14th.

3. These facts, it must be confessed, are unfavorable to the hypothesis, formerly advocated by the writer, that "meteoric stones are but the largest masses in the nebulous rings from which showers of shooting stars are derived."* It is true that in the great star showers of 1799, 1833 and 1866 a number of large fire-balls were seen which belonged undoubtedly to the cluster of Leonids; but it is remarkable that among all this number no detonation was ever heard, and that no meteoric stones have ever fallen during these extraordinary star showers.

4. The dates of the phenomena given above indicate a period of seven years. Several sporadic fire-balls, however, have appeared at this epoch, and no definite conclusion in regard to the period is possible without additional data.

* Meteoric Astronomy, p. 64.

CANADIAN PHOSPHATE.

THE existence of workable deposits of the mineral Apatite in this country has been known for many years, but it has only been quite recently that its value and importance have been fairly recognized. The stimulus imparted to the production of phosphates and the present activity in the market are not the effect of a mere feverish excitement, but arise from the rapid exhaustion of the Peruvian Guano deposits (one authority has stated that at the present rate of consumption but little guano will be left in three years, and fresh discoveries of any importance are unlikely), partly from the great falling off in the production of high grade phosphate in the mines of Spain, France, and the West Indies, whence the principal supplies were drawn, and in part from the constantly increasing demand both in Great Britain and the Continent for active fertilizers.

The value of this manure is determined by the quantity of phosphoric acid it contains, and our product, a fluor-Apatite, is the richest mineral phosphate known. Normally it contains, according to Chapman, phosphoric acid, 42·26; lime, 55·60; fluorine, 3·37; or, phosphate of lime, 92·26; fluoride of lime, 7·74. While low-grade phosphates are abundant in many countries—for example, on the Charleston River in South Carolina there are enormous beds of coprolites, still affording immense quantities, but rarely giving over 50 to 55 per cent.—they are comparatively neglected, and are relatively of much less value than ours, as will be seen by the market prices.

The mineral is sold on the percentage of phosphate of lime it contains, as ascertained by analysis, the standard price being 1s. sterling per unit for all quantities under 70 per cent., while, for 70 per cent. and over, 1s. 3d. to 1s. 3½d. sterling is paid, with an increase of one-fifth of a penny for each additional unit upward. Thus, while a 60 per cent. coprolite is worth in London $14.40, Canadian Apatite of 70 per cent. brings more readily $21; 80 per cent., still readier sale at $25.60; 90 per cent., most wanted, at $30.60. These are last year's prices, but it is expected, from the strong competition manifested, that there will be an advance of at least 1d. per unit, which would make 80 per cent. worth about $27.25 per gross ton in England, or, deducting $7 freight and charges from Montreal, say $20 net per ton at that point.

At this writing there are free buyers in Montreal at $18 to $19 for 80 per cent., cash, a keen competition existing between English and German manufacturers; the same time last year the price was $13.50 to $14. Many large parcels at shipping points on the Ottawa River have changed hands at $16.50 to $17, and in one instance $18 per 2,240 lbs. is mentioned.

The deposits are in the form of irregular and lenticular bunches, or beds and veins, more rarely the latter, and these are of all dimensions from a few pounds to many hundreds of tons. Nearly all the workings are quite superficial, few reaching a greater depth than 10 or 12 feet. The few deep-sinkings as yet tried have been generally quite successful. Some of the largest deposits known have been heavily "capped," and but for perseverance in sinking would have remained undiscovered. It appears, as far as tried, that generally the deposits are somewhat in layers, with hard rock between, at times holding good strong "leads" from one mass to another, but frequently quite cut off, and having no clew to guide. The mineral itself is soft and easily worked, but the associate rocks are often very tough and hard to quarry, so that the cost of production varies with the character and extent of the deposit. Large quantities have been mined at from $1.50 to $2.50 per gross ton at the pits. But an average cost of $8 per ton at the mines, allowing $1.50 to $2.50 for haulage to shipping points, is a fair estimate, and a lower cost should not be counted upon.

The name Apatite, signifying deceiver, is very characteristic of this mineral, from its close resemblance to many others, especially those with which it is placed. Many and grievous errors have been the consequence. An instance is mentioned of work being carried on for months, and several thousand tons of pyroxene, closely resembling phosphate, piled up ready for shipment. The reverse, again, is not by any means infrequent, and an excellent quality, but of a variety not recognized, thrown on the "dump." As more experience is gained, these annoyances will disappear.

In appearance the mineral varies greatly. The first discovered was of a green color, and for several years nothing else was looked for; but now there is every shade from almost white to the deepest bottle green, and a beautiful blue green, and from pale buff to dark brownish red. The structure is also various; when crystallized it is coarsely lamellar, and this form is most readily recognizable; but it merges from this to the granular form known as "Sugar Phosphate," and this graduates again into a very close-grained, dense rock, wholly differing in appearance from the other two, and is very often passed over as useless. Few of the deposits or masses are free from foreign matters. Mica in plates of all sizes is rarely absent; iron pyrites, pyroxene in nodules or crystals, very frequent; lime, feldspar, quartz, etc., also. All these have to be removed by hand-dressing, and upon their thorough removal depends the value of the stuff. Average shipping parcels range from 72 per cent. and 75 per cent. to 80 per cent., choice lots 85 to 87 per cent.: quantities rarely exceed the latter figure.

Canada is celebrated for the beautiful six-sided crystals of this mineral, of every shade and color; these are commonly found imbedded in lime. At the Paris Exhibition there are some enormous blocks of pure phosphate, several of which weigh upward of a ton each. The specimens came from the township of Templeton, and form the foundation of our Canadian trophy.

The great importance of this product will be made clearer, and the outlet for it shown more forcibly, by directing attention to a few facts. A single manufacturer near London, England, requires 1,000 tons of mineral phosphate a week to supply his works. There is a single manufactory in Hamburg which requires from 30,000 to 40,000 tons per annum. Their agents have already purchased several parcels in Montreal. The manufacturers of Antwerp have recently sent orders also. The prices appear to be higher on the Continent than in England; but it is not easy to obtain freights thence. United States parties, with their usual promptitude, have already directed their attention to our product, and have been mining themselves and shipping by rail to New York all the winter. About 300 tons were shipped that way last winter. Besides the large demand for fertilizers, the best qualities of our mineral are taken to the Continent and used as one of the sources of phosphorus, and experiments have been made with a view to using it also in the manufacture of porcelain, instead of ordinary bone-ash.—*Monetary Times, Toronto.*

MINERAL PHOSPHATES.

THE value of phosphate as a fertilizer being so well known, it would seem there is not that attention paid to it which might be expected from its value. There are companies formed for the working of almost every description of minerals, but we are not aware of any engaged in the production of our phosphates, neither are we acquainted with the extent of our deposits of it. That it must be a profitable source of investment may be inferred from the fact that its average value is about £2 8s. per ton. Phosphate of lime, it may be said, is a mixed material. To two atoms of phosphorus there are five atoms of oxygen, constituting phosphoric acid, but it is neutralized with three atoms of lime. Pure phosphate of lime is almost unknown, although some of that obtained in Spain gives as much as 90 per cent. of that important fertilizer. The phosphate of lime in England is found in the chalk marl, which is an argillaceous limestone underlying the true chalk, and is traceable under the entire chalk range from Lynn to the south coast of Dorsetshire, and is associated with the same deposit throughout the entire center of the Wealden country. In Cambridgeshire and Hertfordshire the bed has been worked for the nodules of phosphate, which are of organic origin. In Wiltshire and Dorsetshire the marls are extensively developed, in some instances being nearly 100 ft. in thickness, with organic remains resembling the fauna of the upper greensand. The actual area of the phosphates has not been determined, but we know that the chalk formation in England extends from Flamborough Head through Norfolk, Cambridgeshire, Bedfordshire, and Wiltshire to St. Alban's Head in Dorset. Small quantities of phosphate of lime are raised in Montgomeryshire and Flintshire, in North Wales, and coprolites and phosphatic nodules at Royston, Hitchin, Whaddon, Daxford, etc., the average output of the latter being about 250,000 tons a year. The preparation of mineral phosphates for manure is the same as that adopted with bones. The former is generally broken into pieces and ground between heavy iron rollers into a fine powder, and is then made into superphosphate. In doing so sulphuric acid is used, when the chalk is converted into gypsum. In connection with phosphate of lime in different proportions are the phosphates of iron and aluminium. The phosphate of aluminium is an important article, and has been largely imported from abroad for conversion into alum and crude phosphoric acid, and also into phosphate of soda and alumina. As to our known home supply, it is said that its value was first discovered by the late Dr. Henslow, Professor of Botany at Cambridge, who, on some fossils being shown to him by a farmer, saw at once that they were phosphate of lime, and remarked to the man—"You have found a treasure; not a gold mine, indeed, but a food mine. This is bone earth, which we are at our wits' end to get for our grain and pulse, which we are importing as expensive bones all the way from Buenos Ayres. Only find enough of it, and you will immensely increase the food supply of England." Such is the value of the phosphates that, in addition to our own supplies, we have imported extensively from Spain, Norway, America, the West Indies, etc. The mineral phosphate can be deprived of all its impurities, and so handed over to our farmers. For this purpose muriatic acid is employed. The mineral, being reduced to powder, is treated with a certain amount of acid in a vat, the mixture and the solution being forwarded by a jet of steam from the bottom. By this means the soluble matter is separated from the insoluble, the former containing the whole of the phosphates and the other the useless and worthless refuse.

Phosphates are raised in some parts of France and on the Continent, but not to the extent they might be were greater attention paid to their development. In the Ardennes, the Meuse, and in the Pas-de-Calais, as in England, the fertilizing mineral is found in connection with the cretaceous beds, and in Hainault is found in nodules lying uncomformably on the upper of those rocks. The Craie-brune-de-Cipley, which lies below the Malogne conglomerate, is also phosphatic, but is not worked, although those who are acquainted with the locality consider that it could be profitably raised. The deposits are in the upper chalk, consisting of brownish nodules cemented in a calcareous paste with fragments of indurated chalk and fossils. As a fertilizer phosphate is now in great request, the supply being far below the demand. That it has all properties attributed cannot be doubted, for we know from those who have devoted marked attention to the subject that phosphoric acid, as well as ammonia and salts of potash, are brought down with river sediment, derived from sewage and other impurities, hence the fertility of deltas and alluvial soils. Seeing that the present consumption of mineral phosphates could almost be doubled in England were there a sufficiency at hand, it is plain that there is a large field open for profitable investment in an article that is of the greatest importance to our agriculturists. It would, therefore, be of national benefit were the extent of the deposits even approximately made known to us. Capitalists even at the present time invest in collieries, although they are not paying, and even search for coal in new districts, when they know that more is being raised than is required. On the other hand, there is a new field to which very little attention has been devoted, but which offers every inducement to those who seek for what evidently could not fail to be a highly remunerative investment, and one that would be of the greatest benefit to the country at large by greatly increasing our food supply at a moderate cost.—*Mining Journal.*

THE HOP AS A VEGETABLE.

ALTHOUGH so much grown for its well-known use, and often seen as a climber in small gardens, the hop is little known in England as a vegetable. In Belgium its use as a vegetable is almost universal. The young shoots are cut as soon as they are two inches or three inches above the ground, and boiled in salt and water; they are then dried, and sprinkled with the juice of a lemon to keep them white. Before serving, put them again over the fire for a few minutes, with salt and plenty of butter, then add eggs mixed with milk, when they may be eaten like asparagus, to which they are not inferior. Managed in this way, it makes a most delicate and refined dish. The young shoots of hops are generally cut twice for the sake of strengthening the plants, therefore it would not be advisable to grow hops for their shoots to be used as a vegetable only—when they could be gathered in hop-fields, in gardens, and even in a wild state, all of which are equally good. If this were well known, many of the inhabitants of Kent would add a wholesome dish to their tables, and might even make money by sending the shoots to market.—D. GUIHENEUF, *in The Garden.*

HOT WATER AS A RESTORATIVE FOR PLANTS.

M. WILLERMOZ, in the French "Journal of the Society of Practical Horticulture," relates that plants in pots may be treated with hot water when out of health, the usual remedy for which has been repotting. He says when ill health ensues from acid substances contained or generated in the soil and this is absorbed by the roots, it acts as a poison. The small roots are withered and cease their action, consequently the upper and younger shoots of the plant turn yellow, and the spots with which the leaves are covered indicate their morbid state. In such cases the usual remedy is to transplant into fresh soil, clean the pots carefully, secure good drainage, and often with the best results. But the experience of several years has proved with him the unfailing efficacy of the simpler treatment, which consists of watering abundantly with hot water at a temperature of about 145° Fahrenheit, having previously stirred the soil of the pots so far as might be done without injury to the roots. Water is then given until it runs freely from the pots. In his experiments the water first came out clear, afterward it was sensibly tinged with brown, and gave an appreciable acid reaction. After this thorough washing the pots were kept warm. Next day the leaves of two Ficus elastica so treated ceased to droop, the spread of black spots on the leaves was arrested, and three days afterward, instead of dying, the plants had recovered their normal look of health. Very soon they made new roots, immediately followed by vigorous growth.

MARECHAL NIEL ROSE.

THIS magnificent rose is not so generally cultivated as it merits. In many gardens there is not a respectable-looking plant of it to be found, and in others it is not grown at all—an omission for which nothing else can compensate. When grown in pots or restricted as a dwarf or standard among others in the open air it has no chance of developing its true qualities, and those who only grow it in those ways may just as well not grow it at all. To grow it in all its magnificence it must be planted out in a greenhouse or conservatory, and the branches be allowed to grow to their fullest extent. It is then that armfuls of splendid golden blooms are produced and their great loveliness is fully displayed.

There is no plant in existence that will produce such a quantity of valuable flowers as a Marechal Niel rose, properly grown—and by growing it properly I do not mean that great attention must be paid to it; this it does not require. No plant under glass requires less attention, but what it does have must be of the proper kind. I think there are only two important points in the cultivation of this rose which must have the best attention: the one is to give it plenty of nourishment at the root, and the other is to let the branches extend as much as possible, or at least convenient. A very favorable position is not necessary to its well-being. Back walls and low walls are positions where it will thrive. It may also be grown up pillars or on roofs, but here it is then liable to shade plants underneath.

The best Marechal Niel rose tree I have ever seen for its age is growing on the back wall of a peach house here. Twelve months ago this plant had only three little branches on it, about ten inches or a foot long each. At the present time its aggregare growths are 300 feet long. Last summer it produced shoots as thick as a walking cane, and from 30 to 40 feet long. This spring these shoots emitted branches from every bud, and each of these has terminated in one, two, three, and four blooms, which are just opening. This plant, which twelve months ago was only worth a few pence, is now worth pounds. It is on its roots, and was merely a sucker taken from the bottom of another plant. When it was planted, two or three barrowloads of good loam, with a little lime rubbish and a large quantity of cow-dung, was placed round the roots. There is no means of heating the house, and the rose occupies a strip of wall underneath the standard peach trees on the back wall. The trees on the

trellis in front partially shade it. Ever since it was planted it has never been allowed to become dry at the root, and when it ceased growing in the autumn it was watered just the same as before with liquid manure. The lower shoots are so near the ground that many of the buds are resting on the soil. As many of the blooms will be cut with about a foot of wood and leaves attached, this will be all the pruning it will receive, as the more buds that are left on, the more shoots there will be emitted next spring, and the greater will be the quantity of blooms. Of course it is necessary to thin out the shoots sometimes, but not as long as one branch does not actually rest on the top of another. The more growth there is, the greater demand for support, and rich top-dressings of liquid manure must be given accordingly.

I wish I could say something more strongly in favor of this unique rose; but the truth is it surpasses description; wherever a glass structure is erected for flower growing, Marechal Niel should have a place in it.—M. M., *in Journal of Horticulture.*

RUMINATION.

THE force by which in ruminants food is brought back from the first stomach into the mouth has hitherto been attributed either to the stomach or to the gullet, but exact data have not been furnished with reference to the share of these organs in the process. In a dissertation recently published in Lyons, M. Toussaint describes an experimental investigation of this question. By means of the graphic method he has demonstrated that the cause of the food rising along the gullet is rarefaction of the air in the chest cavity, and so is to be sought in that portion of the gullet which lies in the chest cavity. This rarefaction is produced by a sudden contraction of the diaphragm coinciding with closure of the larynx; thus the food floating in the liquid of the first stomach is sucked into the gullet. A reflex contraction of the right strand of the diaphragm, in consequence of the pressure of the food on the mucous membrane of the gullet, closes the lower end of the gullet, and so limits the quantity of the substance which can pass into this canal; then the food comes quickly into the mouth, and chewing commences.

These various phenomena take place in a very short time, and without the aid of the graphic method it would be impossible to accurately determine their duration and the mode of co-operation of the different organs in the process of rumination. Besides the pressure of the air in the respiratory passages M. Toussaint has graphically determined quite a series of other accompanying phenomena, and from the coincidence in time of a group of the phenomena he has been able to prove the role of the diaphragm in the act of rumination—a role hitherto hardly suspected, but very important.

If the diaphragm be paralyzed by section of its motor nerves, rumination can yet take place through sudden elevation of the ribs, which, instead of the sinking of the diaphragm, operates to cause a diminution of pressure in the chest cavity.

M. Toussaint could also produce rumination artificially. He stimulated the motor nerves of the diaphragm while an assistant stopped the nostrils; in each case a morsel rose along the gullet, the animal chewed it for a few seconds, then swallowed it again.

We will now state the conclusions which M. Toussaint draws from his numerous experiments. They are:

1. That the rarefaction of the air in the chest cavity is the cause of passage of the food from the paunch into the gullet, and that, therefore, no proper previous formation of the morsel occurs; the supposition, therefore, of an organ for forming the morsel is erroneous.

2. That it is necessary, in order that rumination may take place, that the food be very much diluted in that part of the paunch which is next the gullet.

3. That the rarefaction of the air in the lung is produced by a contraction of the diaphragm coinciding with closure of the larynx.

4. That this diminution of pressure within the lung is indispensable for the entrance of substances into the gullet, for if an opening be made into the windpipe, thus neutralizing the action of closure of the larynx, the ribs come to the aid of the diaphragm, and rise suddenly and simultaneously with it, so as at once to produce this diminution of pressure.

5. That in rumination rarefaction of the air is the only force which has to be postulated, and that the stomach is inactive.

6. That the depressing action of contraction of the diaphragm exerts its influence even on the cavities of the heart, and so much the more on the large vessels of the chest cavity.

7. That rumination can be produced artificially by causing a strong contraction of the diaphragm, through stimulation of the proper nerves (nervi phrenici).

M. Toussaint's further experiments on the phenomena of vomiting, retching, and swallowing do not appear to have led to results which are not open to objection.—*Der Naturforscher.*

THE INFECTIOUS NATURE OF YELLOW FEVER.

By JAMES J. L. DONNET, M. D., Inspector General of Hospitals and Fleets; Honorary Surgeon to the Queen.

IN the article, "Is Yellow Fever Infectious?" which appeared in *The Lancet* of the 27th of October last, Dr. Cargill, of Jamaica, has opened a subject of much interest to the medical world at large, and one of vital moment to the inhabitants of the West Indies.

Since the discovery of America by Columbus, the question of the infectious nature of yellow fever has agitated the medical mind, and much diversity of opinion has obtained regarding it, many names of authority being ranged on the side of infection, while as many and as authoritative are found on that of its non-infectious nature. The experience which I have had respecting the various forms of fevers observed in tropical and warm climates (an experience based upon the many instances of these fevers which have fallen under my observation) has forced me to the conclusion that yellow fever proper is a fever of a highly infectious nature, varying in intensity with the degree of virulence which accompanies it, and with the cosmic and atmospheric influences reigning at the time; and I cannot consider the want of unity of opinion which obtains regarding its infectious properties otherwise than as a misconception arising from the seeming analogy which links one form of fever with the other, and which, as a blinding cloud, has shrouded the true nature of the disease and has forced the observers into inferences drawn from erroneous premises.

The shades which separate the symptoms of one fever from those of another, in warm climates, are sometimes of such gentle gradation that *prima facie* they seem to belong to one and the same disease, and this more especially refers to the yellow and remittent class of fevers, between which so slight is sometimes the distinction that remittent has frequently been considered and classified as true yellow fever; for in the prominent symptoms which present in both yellow and remittent fever a great similarity obtains: both take their origin in paludal soils, both in their course offer symptoms of so seemingly similar a nature that the shades which differentiate them are so slight as to frequently escape the conscientious observer and cause him to fall into indefensible interpretations. But this apparent similarity vanishes on close and continuous inspection, for then essential and distinctive marks are observed, which stamp each with an individuality, and which characterize each as a separate disease, distinct in its essence and differing significantly one from the other. These differences may be summarized as follows:

Yellow Fever.	*Remittent Fever.*
Is essentially of an infectious nature.	Is not of an infectious nature.
Only vigorous and young constitutions fall victims to it. Colored population *less* liable than white.	All ages and constitutions are liable, and the weakest most so. Colored population as liable as white.
Restricted to the yellow fever zone—namely, the delta of the Mississippi, and the adjoining coasts and islands.	Is to be found in all parts of the world where marshy soils prevail.
Is of a continued type; no remissions.	Remissions observed in the morning.
Rachialgia more pronounced in this fever than in any other except small-pox.	Rachialgia slight.
Abstraction of blood not tolerated.	Abstraction of blood tolerated.
Albuminous urine the rule.	Albuminous urine the exception.
Liver affected.	Liver not affected.
Spleen not affected.	Spleen invariably affected.
Partial or total suppression of urine the rule.	Suppression of urine the exception.
Hemorrhages from stomach in bad cases the rule.	Hemorrhages from the stomach in bad cases the exception.
Quinine useless as a therapeutic agent.	Antagonistic power of quinine beyond the reach of question.
Death occurs on the fifth day.	Death never occurs before the seventh day.
Yellow fever never merges into intermittent.	Remittent merges into intermittent.
One attack affords an immunity from future ones.	One attack affords no immunity from future ones.
Immunity almost perfect after a three years' residence in the lowlands.	No immunity obtained by any length of residence.
Convalescence less protracted than in remittent fever.	Convalescence protracted.
Peculiar smell in yellow fever cases.	Not observable in remittent fever.

These distinctions are striking; yet there are many who hesitate in determining what the points of contact and divergence are which connect and separate the various forms of malarious disorders. From their having observed yellow fever to coexist with remittent, they believe that both remittent and yellow fever are due to one and the same cause; that upon a reciprocal action of various concurrent agents, and a varied mode of operation of the cause, depend the varied conditions which are observed; and they ask why should not the relation between the two conditions be one of direct causation? These inferences, however, are drawn from observations limited to the habitat of yellow fever, and consequently are not sufficiently cumulative to warrant their acceptance. For if yellow fever and remittent be the offspring of one and the same germ, then yellow fever should be found wheresoever remittent fever has existence; but yellow fever is unknown in the vast marshes at the deltas of the large rivers of the Old World, and in the many localities in which remittent fever luxuriates. This coincidence of the appearance of two disorders in one locality has likewise been noted by others. Sir James M'Grigor observed during the Peninsular war that when men were encamped by the side of some rivers, a part would fall subject to dysentery, while another would be attacked by ague.

While doing duty as medical officer with the men of the Royal Marine Battalion, quartered at St. Jean d'Acre after the fall of that fortress, I observed that while a portion of them fell ill of dysentery, another succumbed to remittent fever. The same thing occurred to the men exposed to the baneful influences of the Gold Coast during the Ashantee campaign, for while some had fever of a remittent type, others suffered from malarious dysentery.

The advocates of the exclusive existence of one germ for the manifestation of two different diseases in one locality allege such examples as the above in support of their theory; the poison, they say, acts variously according to the constitution and the influences reigning at the time. If we admit the theory that one cause alone is sufficient to produce different diseases as distinct in themselves as are yellow and remittent fever, we should then find ourselves in the position of being obliged to break down the barriers which now are generally admitted to divide scarlet fever from measles, yellow fever from plague, typhus fever from typhoid, rabies from hydrophobia, and to accept theories which are diametrically opposed to received opinions, and directly at issue with the facts and evidence which have been solved by accurate research and clinical observation. In the West Indies, simple continued fever and remittent fever may be found coexisting while yellow fever is prevailing and doing its worst; but it does not follow, because different types of fever appear during the prevalence of a more severe one, such as yellow fever is, that any necessary causative connection exists between them.

Whatsoever be the cause or whatsoever the germ which originates yellow fever, there is every reason to believe that it is essentially the cause or specific germ of yellow fever, differing *toto cœlo* from that which produces remittent fever or dysentery; and in the histories of the various epidemics of yellow fever which have occurred since the seventeenth century, whether described by a Ferreira de Rosa, a Simaõ da Cunha, a Chisholm, a Rush, a Blair, or a Louis, this fever is stamped with an individuality which prevents it from being mistaken for plague or remittent or other fever.

Wheresoever malarious diseases have appeared they have been characterized similarly, and although some shades of difference do obtain, as in all types of fever, these diseases have always been identical, in their essential symptoms, with those from whence they have sprung, and have preserved their individuality from ages most remote. The plague which is cradled in the delta of the Nile has always produced the symptoms of plague. Cholera, which is the child of the Sonderbunds of the Ganges, has always produced cholera. Yellow fever, which finds its birth in the delta of the Mississippi, invariably engenders yellow fever. Each has produced nothing more nor less than itself but in degree; and as Professor Tyndall, in his lectures at the Royal Institution, has said: "As surely as a thistle was from a thistle seed, as surely as a fig comes from the fig, the grape from the grape, the thorn from the thorn, so surely does the typhoid fever virus increase and multiply into typhoid fever, the scarlatina virus into scarlet fever, the small-pox virus into small-pox." And so with yellow and remittent fever, each distinct in itself, each having a germ *sui generis*, a germ endowed with like and constant properties, indicated in its effects by special symptoms during life, and specific pathological lesions revealed by examination after death. Remittent fever clothed in similar symptoms reveals itself as remittent and never as yellow fever, while yellow fever assumes an individuality which stamps it as a specific disease, essentially infectious in its nature, distinct and separate from remittent. —*Lancet.*

SUCCESSFUL TREATMENT OF HYDROPHOBIA.

To the Editor of the Lancet: Sir—I think the following case worthy of publication in your journal:

George C——, aged twenty, farm laborer, previously very healthy, no tendency to disease of any kind, was severely bitten on the left hand last summer by a retriever dog, belonging to Major Story, of Mitcham, in Surrey, where the young man was employed. The dog was in a rabid state, and bit a donkey and some pigs, which became rabid, and had to be destroyed; also the dog. Very soon afterward C—— was again bitten by a sheep-dog, which he immediately killed. Within a week or two he began to feel what he described as "twitchings" up the left arm to the shoulder, constantly occurring. Being a strong young fellow, and blessed with happy ignorance, he took no notice of these symptoms, continuing his work there until last January, when he came home to his mother, living in Oxhey lane, about two miles from this town. He complained of, in addition to the twitchings, a curious feeling from the back of his neck down the spine, culminating on the night of Feb. 16th in a violent attack of rabies. Fortunately his mother had the assistance of some young men from the neighborhood, who were obliged to strap him down on his bed to prevent serious mischief.

About two o'clock on the following (Sunday) morning his mother called me up, begging me to go at once and see her son. I went as quickly as possible, and found the young man in a very wretched state. He had bitten himself, and tried to bite others before he was secured. His tongue was swollen, protruding from his mouth, and severely bitten; the muscles of his neck swollen and rigid. I approached him cautiously with some drink, which he dashed from my hand with his head (his head only being free), and had a violent spasm. After a little time I got his attendants (three young men) to turn him, so that I was enabled to apply a strong preparation of cantharides from the nape of his neck down the spine. Not having the proper requisites for a vapor bath, I extemporized one in the best way I could, and succeeded in producing a very free action of the skin, previously hard and dry. After an hour I left him comparatively quiet, and disposed to sleep, the muscles of the neck being less rigid, and he was able partially to swallow. On my visiting him some hours afterward I was informed he had a violent paroxysm during my absence, almost overpowering the young men who remained with him, although still bound down. I commenced giving him the bichloride of mercury every three or four hours, my object being to bring his system under its influence as quickly as possible. The paroxysms continued at intervals, becoming less violent, for some days, entirely ceasing when the salivary glands were affected. He is now tolerably well.

The case has been criticised, and the character of the disease disputed, simply because "*he did not die*"—an extremely weak argument.

In 1871 I reported in your journal my successful treatment of a case of tetanus, then exceptional. Since other cases have been recorded of successful treatment.

In my humble opinion the narcotic or sedative treatment hitherto so universally adopted in hydrophobia tends rather to fix the disease than to eliminate the poison.

Your obedient servant, P. O'HARA BRADY.
Watford, Herts, May 6th, 1878.

ALCOHOL DRESSING IN SCALP WOUNDS.

PROFESSOR GOSSELIN urges the use of alcoholic dressings in contused and lacerated wounds of the scalp. He says that whatever this dressing may be with regard to other parts of the body, in wounds of the head it seems to be that which gives the patient the most protection from consecutive accidents and leads to the quickest cicatrization. So treated, these wounds have less tendency to inflammation and suppuration, are cured quickly, and are less often attended with erysipelas and phlegmonous inflammation.

COLOR BLINDNESS.

DR. LEDERER, a naval surgeon, in an elaborate paper in the *Wien. Med. Wochenschrift* (1878, Nos. 2 and 4) states that the observations which he made upon 1,300 individuals lead him to the following conclusions:—1. That color blindness, properly so called, in its strictly scientific sense, is a very rare occurrence. 2. People who are not always conversant with colors are pretty numerous; and this should be borne in mind in selecting those who have to be engaged on important services with colored signals. It would be incorrect, however, to regard all such persons as subjects of color blindness.

NUMBER OF PULSATIONS OF THE HEART.

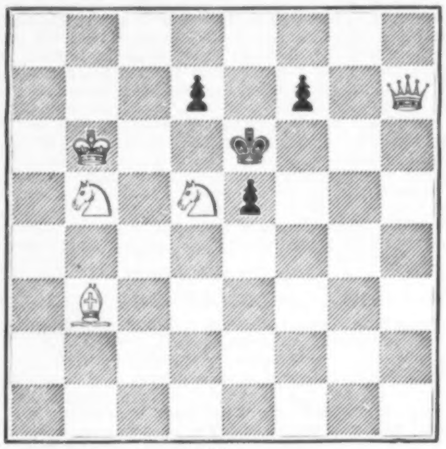
DR. GUYOT estimates the average number of pulsations of the heart at a little less than forty millions per annum; during a life of fifty years, 1,928,160,000; during a life of sixty years, 2,269,800,000; and during a life of eighty years, 3,007,040,000. To these figures, applicable to an individual in constant good health, have to be added the pulsations of fetal life, calculated at 27,216,000. The total number of contractions in a centenarian would amount to 3 milliards 792 millions and 550,000, or nearly 4 milliards.

SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department may be addressed to SAMUEL LOYD, Elizabeth, N. J.]

PROBLEM No. 88. BY CARPENTER OR SHINKMAN(?).
Best two-mover in the Huddersfield College Tourney No. 1.

Black.



White.

White to play and mate in two moves.

F. E. BRENZINGER, OF NEW YORK.

White to play and mate in 3 moves. ASSOCIATION LETTER TOURNEY.

VERY recently we gave an account of a consultation match played at the Café International, and gave the portraits of the gallant Captain and victorious allies. Having given a likeness of Mr. Mason, we now give that of his right hand man in this memorable contest, Mr. F. E. Brenzinger, well known in chess circles as one of our leading metropolitan players. Mr. Brenzinger, as his name would indicate, is of German extraction, and is in all probability the strongest German player in the country, having been a most remarkably successful tournament and match player. He came to New York when quite a lad, and learned the moves young, and has practiced the game continually for a quarter of a century, his skill being greatly—if not entirely—due to his practice with problems, in which branch he is quite an adept.

We were cronies together at the old Morphy Chess Rooms some twenty years ago and spent much of our time in problem building. At that time we expected great things of him as he was looked upon as one of our most ingenious and clever composers. We remember his making the following little problem at that time, which will compare favorably with his more recent works:

ENIGMA No. 56.—BY F. E. BRENZINGER.

White.—K on K sq, Q Q Kt sq, B Q B 8, Kt K 8.
Black.—K on K 4.
White to play and mate in three moves.

He has recently patented a portable chess companion in the shape of a folding board, that is very handy for traveling and preserving the position of a game.

A CHAPTER ON CHESS BOARDS.

THE distinction of color in the chess board is comparatively modern. The Asiatic and African boards are to this day of a single color divided into squares. A traveler relates that he saw Moors sitting upon the ground, which had been marked off into a rude chess board, and playing chess with black and white pebbles of different sizes. Louis XIII., of France, had a board quilted with wool, the men being fitted with a sharp point at the bottom. By means of this the monarch used to play in his carriage, sticking the men into the cushion. The most convenient size for a chess board is a field sixteen inches square. We have seen boards made of heavy plate glass, having the squares in black and white velvet beneath the glass. The board used by Charles V. is still in existence. Its squares are of alternate ebony and ivory. La Bourdonnais, who played with astonishing rapidity, was the first to introduce the custom of piercing the sides of the chess board, in order to mark with small pegs the number of games played at a sitting. The inventor of the pocket boards, lately published by the Appletons, is Dr. P. M. Roget, the author of the "Treasures of English Words." The board used by Al-Mamun, caliph of Bagdad, was two cubits square. An *arrêt* of the Parliament of Paris, dated 1320, mentions a chess table made of jasper and chalcedony. In the old romance of "Ogier le Danois," Chariot, the king's son, kills Baldwin with a golden chess board. In the Swedish poem, "Frithiof's Saga," by Tegner, the hero and his friend Bjorn play upon a board of which it is said that

"Silver was each alternate square,
And each alternate square was gold."

Teilor, a German writer, describes a liliputian chess board only one inch square, having every square perfect. The men which accompanied it could all be placed in a common quill.

Ten years ago Mr. Loyd invented and designed a picturesque chess board, each square of which contained the likeness of some distinguished chess celebrity. A short time since Mr. H. F. L. Meyer, of London, issued a similar design, limiting his selection however to English players, Mr. Hugh Bryan, of Ayr, Scotland, has just completed a photographic chess board, as a memento of the present international correspondence match, in which the 58 players participating in this remarkable contest are photographed upon the squares, the remaining six squares being complimentary to special guests. Mrs. Gilbert represents the white queen, and Mr. Gossip, her British antagonist, the king. Mr. Loyd is honored with the position of the adverse king, with Miss Rudge as his queen, for which compliment he most respectfully doffs his cap.

THE following game was played at the Café International Tournament, 1876, between Messrs. Brenzinger and Ensor:

[*Ruy Lopez.*]

MR. BRENZINGER. WHITE.	MR. ENSOR. BLACK.
1. P to K 4	1. P to K 4
2. Kt to K B 3	2. Kt to Q B 3
3. B to Kt 5	3. B to B 4
4. P to Q B 3	4. P to Q R 3
5. B to R 4	5. P to Q Kt 4

The advance of these pawns is unfavorable to him, but a natural consequence of his third move, which is universally condemned.

6. B to B 2	6. P to Q 3
7. Castles.	7. B to K Kt 5
8. P to Q 3	8. Q to B 3
9. B to K 3	9. B x Kt
10. P x B	10. B to R 2
11. K to R sq	11. K Kt to K 2
12. R to K Kt sq	12. P to R 3
13. P to Q 4	

It looks as if white was determined to hasten his attack at all hazards; but a more conservative course would need no justification.

	13. P x P
14. P x P	14. B x P
15. Kt to B 3	15. B to K 4

Here we think he ought to have played B x Kt, following with P to K Kt 4, Kt to K 4 and K Kt to Kt 3.

16. Kt to Q 5

F. EUGENE BRENZINGER.

The weakness of black's queen's side is now apparent. He must take this knight, and at a loss.

	16. Kt x Kt
17. Q x Kt	17. Q x P ch
18. R to Kt 2	18. K to Q 2

Castling was a better move, seeing that the piece could not be saved.

19. B to Q sq	19. Q to B 3
20. B to Kt 4 ch	20. K to K 2
21. Q x Kt	21. K R to Q sq
22. Q x B P ch	22. K to B sq
23. K B to B 5	23. B x Kt P
24. Q R to K Kt	24. Q to K 2
25. Q to B 2	25. B to B 3
26. B x R P	

The ending is exceedingly well played by Mr. Brenzinger.

	26. Q to K 4
27. Q to B 7	27. P to R 4
28. P to B 4	28. Q to B 6
29. Q x Q	29. B x Q
30. R x P	30. B x R
31. R x B	31. K to K 2
32. B to Kt 5 ch	32. K to B sq
33. R to R 7 ch	33. R to K sq
34. B to B 6 and wins.	

THE HUDDERSFIELD COLLEGE TOURNEY No. 1.

IN this interesting problem tourney, the award of which was published in the college magazine for April, we learn that the first prize was awarded to Mr. J. H. Finlinson, of Huddersfield, England.

The second prize to Mr. G. J. Slater.

The third prize to Mr. W. Coates.

Special prizes for the best two-mover to W. A. Shinkman.

For the best three move problem to Mr. J. H. Finlinson.

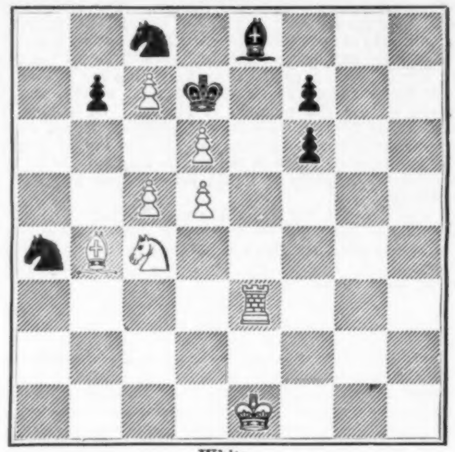
For the best four-movers Messrs. G. J. Slater and F. W. Martindale.

There were fifteen competitors, and the umpire, Mr. Andrews, speaks most highly of the merits of the problems, but the editors of the magazine have not yet complied with the established custom of reproducing the winning problems accompanied by the authors' names, so we find it impossible to give a collection of the winning sets, and confine our selection to two of the special prizes, which have fallen to the lot of our countrymen, Mr. W. A. Shinkman and Mr. F. W. Martindale.

In the awarding of the prize to Mr. Shinkman a curious coincidence occurred that not unfrequently happens in a more limited degree in the ordinary publication of problems, but never before, we believe, in so important a case as the deciding of a prize. It happens that the problem to which the two move prize is awarded is a well-known problem by Mr. George E. Carpenter, contributed for publication—in the exact form—over a year before the date of the time that Mr. Shinkman composed it. Mr. Shinkman is one of the most prolific, ingenious and original composers the world has ever produced, having composed over 1,200 problems, which is nearly twice that of any other composer. It is no wonder, therefore, that his fertile brain should have hit upon the same idea as Mr. Carpenter, and it is fortunate that his reputation is so high that all must admit it to be a clear case of great minds running in the same channel—Mr. Carpenter having an undisputed right of way by more than a year priority.

PROBLEM No. 89. BY F. W. MARTINDALE.
Prize in Huddersfield College Magazine Tourney, No. 1.

Black.



White.

White to play and mate in four moves.

CHESS IN LITERATURE.

POETS, orators, historians, and philosophers have frequently illustrated their writings by metaphors drawn from the royal game. The following by the eminent Prof. Huxley, extracted from an excellent essay on education, is one of the finest parallels we have ever seen:

"Suppose it were perfectly certain that the life and fortune of every one of us would, one day or other, depend upon his winning or losing a game at chess. Don't you think that we should all consider it to be a primary duty to learn at least the names and the moves of the pieces; to have a notion of a gambit, and a keen eye for all the means of giving and getting out of check? Do you not think that we should look with a disapprobation amounting to scorn upon the father who allowed his son, or the State which allowed its members, to grow up without knowing a pawn from a knight? Yet it is a very plain and elementary truth that the life, the fortune, and the happiness of every one of us, and, more or less, of those who are connected with us, do depend upon our knowing something of the rules of a game infinitely more difficult and complicated than chess. It is a game which has been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chess board is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of Nature. The player on the other side is hidden from us. We know that his play is always fair, just and patient. But also we know, to our cost, that he never overlooks a mistake or makes the smallest allowance for ignorance. To the man who plays well the highest stakes are paid, with that sort of generosity with which the strong shows delight in strength. And one who plays ill is checkmated—without haste, but without remorse.

"My metaphor will remind some of you of the famous picture in which Retzsch has depicted Satan playing at chess with a man for his soul. Substitute for the mocking fiend in that picture a calm, strong angel who is playing for love, as we say, and would rather lose than win—and I should accept it as an image of human life. Well, what I mean by education is learning the rules of this mighty game."

SOLUTIONS TO PROBLEMS.

No. 82.—BY S. LOYD.

WHITE.	BLACK.
1. R to Q Kt 2	1. R x Q
2. Kt to Q B 5 ch	2. K to B 6
3. Kt to R 4 mate.	
	1. R x Kt or chs
2. Q x R ch	2. Moves
3. Q mates.	

No. 83.—BY ISAAC S. LOYD.

WHITE.	BLACK.
1. Q to Q R 8!	1. B to Q R 5 (best)
2. Q to K R sq!!	2. B to Q 8
3. Q x B	3. Q x Kt
4. Q to Q R sq	4. Any
5. Kt to K 2 mate.	

LETTER "A."—BY E. B. COOK.

WHITE.	BLACK.
1. P to Q R 3	1. Any
2. B or Q mates.	

ENIGMA No. 48.—BY S. LOYD.

WHITE.	BLACK.
1. R x Kt ch	1. K x R
2. R to Q 2 ch	2. K x R
3. Q to K sq ch	3. K x Q
4. B to Q B 4 mate.	

ENIGMA No. 49.—BY T. M. BROWN.

WHITE.	BLACK.
1. Q to B 5 ch	1. P x Q
2. R x B	2. Q x R
3. Kt to K B 4	3. Q to Q 8 ch
4. P to Kt 3 ch	4. Q x P
5. P x Q mate.	